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The Emissions Gap Report 2012

A UNEP Sythesis Report

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Total number of authors:
11

Publication date:
2012

Document Version
Publisher's PDF, also known as Version of record

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Published by the United Nations Environment Programme (UNEP), November 2012

ISBN: 978-92-807-3303-7
DEW/1614/NA

Citation
This document may be cited as:
UNEP 2012. The Emissions Gap Report 2012. United Nations Environment Programme (UNEP), Nairobi

A digital copy of this report can be downloaded at http://www.unep.org/publications/ebooks/emissionsgap2012/

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UNEP

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Acknowledgements

The United Nations Environment Programme (UNEP) would like to thank the Steering Committee, the Lead and Contributing Authors, and the Secretariat for their contribution to the development of this report.

The following individuals have provided input to the report. Authors and reviewers contributed to this report in their individual capacity and their organizations are only mentioned for identification purposes.

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Secretariat and Media Support – Harsha Dave (UNEP); Nikola Franke (European Climate Foundation); Sunday A. Leonard (UNEP); Kelvin Memia (UNEP); Mette Annelie Rasmussen (UNEP Risoe Centre); Shereen Zorba (UNEP).

Production Team – Robsondowry Ltd; Pouran Ghaffarpour (United Nations Office at Nairobi); Eugene Papa (United Nations Office at Nairobi).

Printing – UNON, Publishing Services Section, ISO 14001:2004 - certified

UNEP would also like to thank the following individuals from around the world for their valuable comments, editorial support, provision of data and valuable advice: Sarah Abdelrahim (UNEP); Laura Bates (Department for Energy and Climate Change); Kate Calvin (Pacific Northwest National Laboratory); Erin Cooper (EMBARQ); Laura Cozzi (International Energy Agency); Donovan Escalante (Ecofys); Seraphine Haeussling (UNEP); Nicholas Harrison (Ecofys); Ifeanyi Iregbu (UNEP); Peter Kolp (International Institute for Applied Systems Analysis); Volker Krey (International Institute for Applied Systems Analysis); Birgitte Smith Lange (UNEP Risoe Centre); Sara Moltmann (Ecofys); Daniel Puig (UNEP Risoe Centre); Lori Siegel (Climate Interactive); Massimo Tavoni (Fondazione Eni Enrico Mattei); Xiao Wang (UNEP Risoe Centre); and Kaveh Zahedi (UNEP).

UNEP also wishes to thank the Government of the United Kingdom of Great Britain and Northern Ireland, and in particular, the Department for Energy and Climate Change (DECC) for providing funds to partly support the 2nd Authors Workshop during the development of this report.

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Glossary

Annex I Countries – the industrialised countries (and those in transition to a market economy) which took on obligations to reduce their greenhouse gas emissions under the United Nations Framework Convention on Climate Change.

Aerosols – are collections of airborne solid or liquid particles, with a typical size between 0.01 and 10 micrometer (a millionth of a meter) that reside in the atmosphere for at least several hours. They may influence the climate directly by scattering and absorbing radiation, and indirectly by acting as cloud condensation nuclei or modifying the optical properties and lifetime of clouds.

BioCCS (Bioenergy and Carbon Capture and Storage) – is the use of energy produced from biomass where the combustion gases are then captured and stored underground or elsewhere.

Black Carbon – a form of air pollution consisting of carbon particles produced by incomplete combustion of fuels. It is produced especially by diesel-powered vehicles, open biomass burning, cooking stoves and other sources.

'Bottom up' Model – a model which represents reality by aggregating characteristics of specific activities and processes, considering technological, engineering and cost information.

Business-as-Usual – a scenario used for projections of future emissions assuming no action, or no new action, is taken to mitigate emissions.

Carbon Credits – tradeable permits which aim to reduce greenhouse gas emissions by giving them a monetary value.

Carbon Dioxide Equivalent (CO_2e) – a simple way to place emissions of various climate change agents on a common footing to account for their effect on climate. It describes, for a given mixture and amount of greenhouse gas, the equivalent weight of carbon dioxide that would have the same global warming ability, when measured over a specified timescale. For the purpose of this report, greenhouse gas emissions (unless otherwise specified) are the sum of the basket of greenhouse gases listed in this glossary under the entry: "Greenhouse Gases covered by the Kyoto Protocol".

Carbon Leakage – according to the IPCC, carbon leakage occurs when there is an increase in carbon dioxide emissions in one country as a result of an emissions reduction by a second country. For example, an increase in local fossil fuel prices resulting from mitigation policies may lead to the re-allocation of production to regions with less stringent mitigation rules (or with no rules at all), thus causing higher emissions in those regions.

Conditional Pledges – pledges made by some countries that may be contingent on the ability of national legislatures to enact the necessary laws, or ambitious action from other countries, or realisation of finance and technical support, or other factors.

Double Counting – in the context of this report, "double counting" refers to a situation in which the same emission reductions are counted towards meeting two countries' pledges.

Emissions Pathway – the trajectory of annual global greenhouse gas emissions over time.

EU27 – The 27 Member States of the European Union.

Global Warming Potential (GWP) – A relative index that enables comparison of the climate effect of the emissions of various greenhouse gases (and other climate changing agents). Carbon dioxide, the greenhouse gas that causes the greatest radiative forcing because of its overwhelming abundance, is chosen as the reference gas.

Greenhouse Gases covered by the Kyoto Protocol – include the six main greenhouse gases, as listed in Annex A of the Kyoto Protocol: Carbon dioxide (CO_2); Methane (CH_4); Nitrous oxide (N_2O); Hydrofluorocarbons (HFCs); Perfluorocarbons (PFCs); and Sulphur hexafluoride (SF_6).

Integrated Assessment Models – are models of climate change that seek to combine knowledge from multiple disciplines in the form of equations and/or algorithms. As such, they describe the full chain of climate change, including relevant linkages and feedbacks between socio-economic and biophysical processes.

Kyoto Protocol – the international environmental treaty intended to reduce greenhouse gas emissions. It adds additional provisions to the United Nations Framework Convention on Climate Change.

Lenient Rules – pledge cases with maximum Annex I "lenient LULUCF credits" and surplus emissions units.

Likely Chance – a greater than 66% likelihood. Used in this report to convey the probability of meeting temperature limits.

Medium Chance – a 50 to 66% likelihood. Used in this report to convey the probability of meeting temperature limits.

Montreal Protocol – the multilateral environmental agreement dealing with the depletion of the earth's ozone layer.

Non-Annex I Countries – a group of developing countries that have signed and ratified the United Nations Framework Convention on Climate Change. They do not have binding emission reduction targets.

Pledge – for the purpose of this report, pledges include Annex I targets and non-Annex I actions as included in Appendix I and Appendix II of the Copenhagen Accord.

Radiative Forcing (RF) – is the global mean radiation imbalance over the radiation 'budget' of the earth's atmosphere. A positive forcing warms the system, while a negative forcing cools it.

Scenario – a description of how the future may unfold based on 'if-then' propositions. Climate change scenarios typically include an initial socio-economic situation and a description of the key driving forces and future changes in emissions, temperature, or other climate change-related variables.

Strict Rules – pledge cases in which the impact of "lenient LULUCF credits" and surplus emissions units are set to zero.

'Top down' Model – a model that applies macroeconomic theory, econometric and optimisation techniques to aggregate economic variables. Using historical data on consumption, prices, incomes, and factor costs, top-down models assess final demand for goods and services, and supply from main sectors, such as the energy sector, transportation, agriculture and industry.

Transient Climate Response – is a measure of the strength and rapidity of the surface temperature response to greenhouse gas forcing, according to the IPCC.

20^{th} – 80^{th} percentile range – results that fall within the 20-80% range of the frequency distribution of results in this assessment.

Unconditional Pledges – pledges made by countries without conditions attached to their fulfilment.

Acronyms

BaU	Business-as-Usual
BC	Black Carbon
BRT	Bus Rapid Transit
BUENAS	Bottom-up Energy Analysis System
CCS	Carbon Capture and Storage
CDM	Clean Development Mechanism
CFC	Chlorofluorocarbon
CO_2e	Carbon Dioxide Equivalent
COP	Conference of the Parties to the United Nations Framework Convention on Climate Change
GDP	Gross Domestic Product
GEA	Global Energy Assessment
GHG	Greenhouse Gas
Gt	Gigatonne (1 billion tonnes)
GW	Gigawatt
HFCs	Hydrofluorocarbons
IAM	Integrated Assessment Model
ICAO	International Civil Aviation Organization
IEA	International Energy Agency
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
LBNL	Lawrence Berkeley National Laboratory
LULUCF	Land Use, Land-Use Change and Forestry
MW	Megawatt
NAMA	Nationally Appropriate Mitigation Action
OC	Organic carbon
PAMS	Policy Analysis Modelling System
PES	Payments for Ecosystem Services
PV	Photovoltaic
RE	Renewable Energy
REDD+	Reduced Emissions from Deforestation and Forest Degradation
SEAD	Super-efficient Equipment and Appliance Deployment
SRREN	IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation
UNFCCC	United Nations Framework Convention on Climate Change

Foreword

This third Emissions Gap Report provides a sobering assessment of the gulf between ambition and reality in respect to keeping a global average temperature rise this century under 2 degrees Celsius.

As in previous Gap reports, designed to inform governments in advance of the annual Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change and empower scaled-up action, the analysis focuses on how nations are faring towards bringing emissions down to around 44 gigatonnes of CO_2 equivalent or less by year 2020.

The result of this year's analysis shows that without action, emissions are likely to be at 58 gigatonnes (Gt) in eight years' time, leaving a gap that is now bigger than it was in earlier assessments, as a result of projected economic growth in particular in key developing economies.

Even if the most ambitious level of pledges and commitments were implemented by all countries under the strictest set of rules, the analysis shows that there would still be a gap of 8 Gt of CO_2 equivalent by 2020. This is 2 Gt higher than last year's assessment with yet another year passing by.

Can the gap be bridged by 2020? From a technical standpoint the answer remains yes with an estimated potential to bring down emissions by 17 Gt by the 2020 timeline – the challenge is that current investments in buildings, transportation systems, factories, and other infrastructure are "locking in" high energy use patterns and associated emissions for decades, limiting future options for abating emissions.

The 2012 Report for the first time reviews a number of successful policy actions that have been effective in substantially reducing emissions at the national level. For example, appliance standards, performance standards for vehicles, and economic incentives to reduce deforestation to name but three.

Many of these are being implemented for reasons other than climate change and they are generating multiple 'Green Economy' benefits and opportunities right across the sustainable development landscape.

Replicating these successful policies and scaling them up would provide one way for countries to go beyond their current pledges and assist in closing the gap. Under the UN climate convention negotiations, governments are working to a new international agreement by 2015 to become operational by 2020. The Emissions Gap Report 2012 underlines the importance of strong global action post 2020, but emphasizes that unless action to close the Gap is taken urgently, the longer term challenge may be insurmountable or at best, very costly.

Achim Steiner
UN Under-Secretary-General,
UNEP Executive Director

Executive Summary

One of the fundamental questions in the global climate negotiations is: what level of "ambition", in terms of collective emission reductions, is needed to protect global climate? To help answer this question UNEP and the scientific community have published a series of reports on the "emissions gap[1]" since 2010. Of particular interest to the ambition question is the gap in 2020 between emission levels consistent with the 2°C climate target and emissions levels projected if country reduction pledges are fulfilled. If there is a gap, then there is doubt that the ambition of countries is great enough to meet the agreed-upon 2°C climate target

In the 2010 *Emissions Gap Report,* scientists indicated that there would likely be a substantial emissions gap in 2020, although estimates of this gap ranged widely, depending on assumptions about how country pledges would be complied with. In the 2011 *Bridging the Emissions Gap Report*, scientists noted that enough technical potential existed to close the gap in 2020, but fast action by countries was needed.

UNEP has now convened a group of 55 scientists and experts from 43 scientific groups across 22 countries to produce this third emissions gap report which covers the following:

- An update of global greenhouse gas emission estimates, based on a number of different authoritative scientific sources;
- An overview of national emission levels, both current (2010) and projected (2020) consistent with current pledges and other commitments;
- An estimate of the level of global emissions consistent with the two degree target in 2020, 2030 and 2050;
- An update of the assessment of the emissions gap for 2020;
- A review of selected examples of the rapid progress being made in different parts of the world to implement policies already leading to substantial emission reductions. These policies could contribute significantly to narrowing the gap if they are scaled up and replicated in other countries.

1 The "emissions gap" is the difference in 2020 between emission levels consistent with the 2°C limit and projected emission levels.

1. What are current global emissions?

Current global emissions are already considerably higher than the emissions level consistent with the 2°C target in 2020 and are still growing.

Current global greenhouse gas emissions, based on 2010 data from bottom-up emission inventory studies, are estimated at 50.1 $GtCO_2e$ (with a 95% uncertainty range of 45.6 - 54.6). This is already 14% higher than the median estimate (44 $GtCO_2e$) of the emission level in 2020 with a likely chance of meeting the 2°C target. This is also about 20% higher than emissions in 2000. Global emissions are now picking up again after their decline during the economic downturn between 2008 and 2009. Modeling groups use a median value of 49 $GtCO_2e$ for 2010, which is within the uncertainty range. The figure of 49 $GtCO_2e$ is used throughout the rest of the report unless otherwise noted.

2. What is the latest estimate of the Emissions Gap in 2020?

The estimated emissions gap in 2020 for a "likely" chance of being on track to stay below the 2°C target is 8 to 13 $GtCO_2e$ (depending on how emission reduction pledges are implemented), as compared to 6 to 11 $GtCO_2e$ in last years' Bridging the Emissions Gap Report. The gap is larger because of higher than expected economic growth and the inclusion of "double counting"[2] of emission offsets in the calculations.

The assessment clearly shows that country pledges, if fully implemented, will help reduce emissions to below the Business-as-Usual (BaU) level in 2020, but not to a level consistent with the agreed upon 2°C target, and therefore will lead to a considerable "emissions gap".

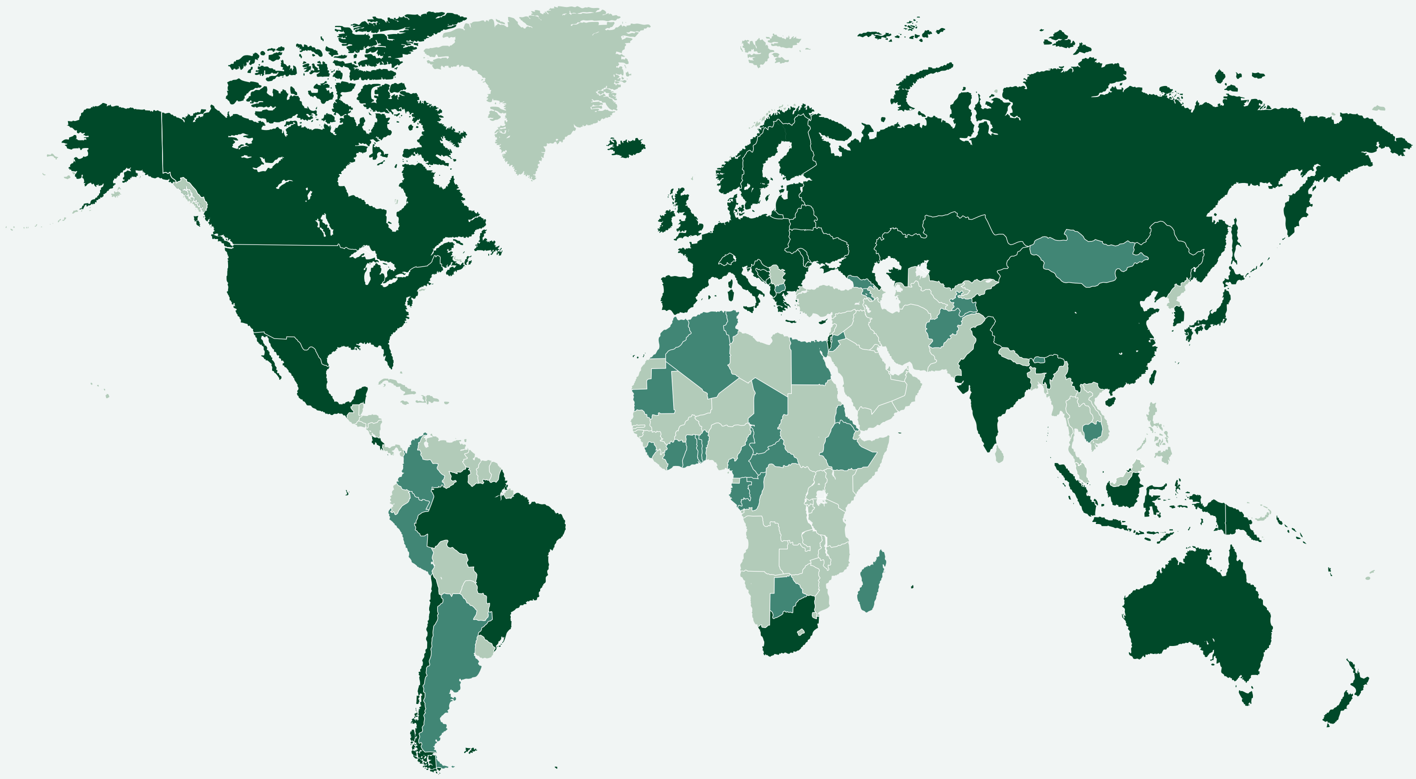
As a reference point, the emissions gap in 2020 between BaU emissions and emissions with a "likely" chance of meeting the 2°C target is 14 $GtCO_2e$.

As in previous reports, four cases are considered which combine assumptions about pledges (unconditional or

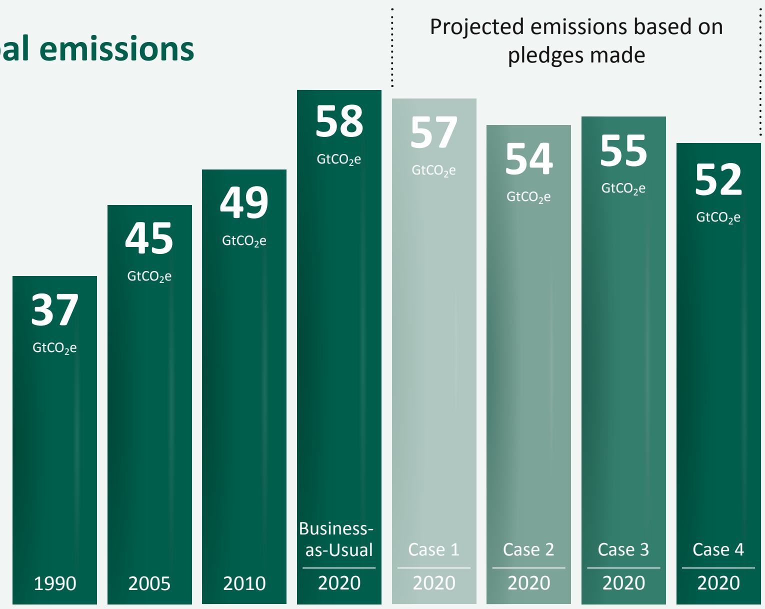
2 In the context of this report, "double counting" refers to a situation in which the same emission reductions are counted towards meeting two countries' pledges.

Global map showing the different categories of pledges

Pledges formulated in terms of GHG emissions — Submitted actions — No pledge



Estimated global emissions



Case 1 – Unconditional pledges, lenient rules
If countries implement their lower-ambition pledges and are subject to "lenient" accounting rules, then the median estimate of annual GHG emissions in 2020 is 57 $GtCO_2e$, within a range of 56 – 57 $GtCO_2e$.

Case 2 – Unconditional pledges, strict rules
This case occurs if countries keep to their lower-ambition pledges, but are subject to "strict" accounting rules. In this case, the median estimate of emissions in 2020 is 54 $GtCO_2e$, within a range of 54 – 55 $GtCO_2e$.

Case 3 – Conditional pledges, lenient rules
Some countries offered to be more ambitious with their pledges, but link that to conditions. If the more ambitious conditional pledges are taken into account, but accounting rules are "lenient", median estimates of emissions in 2020 are 55 $GtCO_2e$ within a range of 54 – 56 $GtCO_2e$.

Case 4 – Conditional pledges, strict rules
If countries adopt higher-ambition pledges and are also subject to "strict" accounting rules, the median estimate of emissions in 2020 is 52 $GtCO_2e$, within a range of 51 – 52 $GtCO_2e$.

Please note: All emission values shown in the text are rounded to the nearest gigatonne.

conditional) and rules for complying with pledges (lenient or strict) (See footnote[3] for an explanation).

- Under Case 1 – "Unconditional pledges, lenient rules", the gap would be about 13 $GtCO_2e$ (range: 9-16 $GtCO_2e$). Projected emissions are about 1 $GtCO_2e$ lower than the business-as-usual level.
- Under Case 2 – "Unconditional pledges, strict rules", the gap would be about 10 $GtCO_2e$ (range: 7-14 $GtCO_2e$). Projected emissions are about 4 $GtCO_2e$ lower than the business-as-usual level.
- Under Case 3 – "Conditional pledges, lenient rules", the gap would be about 11 $GtCO_2e$ (range: 7-15 $GtCO_2e$). Projected emissions are about 3 $GtCO_2e$ lower than the business-as-usual level.
- Under Case 4 – "Conditional pledges, strict rules", the gap would be about 8 $GtCO_2e$ (range: 4-11 $GtCO_2e$). Projected emissions are about 6 $GtCO_2e$ lower than the business-as-usual level.

There is increasing uncertainty that conditions currently attached to the high end of country pledges will be met and in addition there is some doubt that governments may agree to stringent international accounting rules for pledges. It is therefore more probable than not that the gap in 2020 will be at the high end of the 8 to 13 $GtCO_2e$ range.

On the positive side, fully implementing the conditional pledges and applying strict rules brings emissions more than 40% of the way from BaU to the 2°C target.

To stay within the 2°C limit global emissions will have to peak before 2020[4]

Emission scenarios analyzed in this report and consistent with a "likely" chance of meeting the 2°C target have a peak before 2020[5], and have emission levels in 2020 of about 44 $GtCO_2e$ (range: 41-47 $GtCO_2e$). Afterwards, global emissions steeply decline (a median of 2.5% per year, with a range of 2.0 to 3.0% per year)[6]. Forty percent of the assessed scenarios with a "likely" chance to meet the 2°C target have net negative total greenhouse gas emissions before the end of the century 2100. The implications of net negative emissions are discussed in Point 4.

Accepting a "medium" (50-66%) rather than "likely" chance of staying below the 2°C limit relaxes the constraints on emission levels slightly, but global emissions still peak before 2020.

The few studies available indicate that a 1.5°C target can still be met

Emissions in 2020 are lower in scenarios meeting the 1.5°C target compared with the 2°C level. The few scenarios available for this target indicate that scenarios consistent with a "medium" chance of meeting the 1.5°C limit have average emission levels in 2020 of around 43 $GtCO_2e$ (due to the limited number of studies no range was calculated), and are followed by very rapid rates of global emission reduction, amounting to 3% per year (range 2.1 to 3.4%). Some studies also find that some overshoot of the 1.5°C limit over the course of the century is inevitable.

3. What emission levels in 2030 and 2050 are consistent with the 2° and 1.5°C targets?

Scenarios that meet the 2°C limit show a maximum emission level in 2030 of 37 $GtCO_2e$

Given the Durban decision to complete negotiations on a new treaty by 2015 for the period after 2020, it has become increasingly important to know the global emission levels in 2030 that are likely to comply with the climate targets. The emission scenarios assessed in this report and consistent with a "likely" chance of meeting the 2°C target have global emissions in 2030 of approximately 37 $GtCO_2e$ (range: 33 to 44 $GtCO_2e$). This is around the same level of emissions as in 1990. It is important to emphasize that the 2030 range depends on where emissions are in 2020. The higher the emissions in 2020, the lower they must be by 2030.

Scenarios that meet the 2°C limit have global emissions in 2050 roughly 40% below 1990 emission levels and roughly 60% below 2010 emission levels.

Scenarios with a "likely" chance of complying with the 2°C target have global emissions in 2050 of approximately 21 $GtCO_2e$ (range: 18 to 25 $GtCO_2e$), if the 2020 and 2030 levels indicated above are met.

4. What are the implications of scenarios that meet the 2020 emission levels consistent with 1.5°C and 2°C?

As noted above, 40% of the assessed scenarios with a "likely" chance to meet the 2°C target have net negative total greenhouse gas emissions before the end of the century. The *majority* of scenarios have net negative CO_2 emissions at some point in the second half of this century in the global energy and industry sectors.

"Net negative emissions" means that on a global basis more greenhouse gases are taken up from the atmosphere by deliberate actions (e.g. by planting forests or through carbon capture and storage) than what is emitted by anthropogenic sources. Individual technologies or sectors may also generate a "net negative emission" specifically related to their actions.

To achieve such negative emissions is simple in analytical models but in real life implies a need to apply new and often unproven technologies or technology combinations at significant scale.

As an example, many studies that meet the 2°C target assume a significant deployment of bioenergy combined with carbon capture and storage (BioCCS), to achieve net

3 In this report, an "unconditional" pledge is one made without conditions attached. A "conditional" pledge might depend on the ability of a national legislature to enact necessary laws, or may depend on action from other countries, the provision of finance, or technical support. "Strict" rules mean that allowances from LULUCF accounting and surplus emission credits will not be counted as part of a country meeting its emissions reduction pledges. Under "lenient" rules, these elements can be counted.

4 This is the case for scenarios using least cost pathways; see Chapter 3 for detailed explanation.

5 Global annual emissions consist of emissions of the "Kyoto basket of gases" coming from energy, industry and land use.

6 Throughout this report average emission reduction rates from 2020 to 2050 are given for carbon dioxide emissions from energy and industry and expressed relative to 2000 emission levels except where explicitly otherwise stated.

negative CO_2 emissions in the industry and energy sectors or even net negative total global emissions. The feasibility and consequences of such large-scale bioenergy systems will need to be closely examined because of their possible impact on food production and biodiversity, the possible lack of sufficient land and water, and questions about the long-term productivity of biomass feedstocks. The application of carbon capture and storage (CCS) is still fraught with controversy and large scale application and safe CO_2 disposal has not yet been fully verified. If net negative CO_2 emissions at a significant scale are proven later to be infeasible, a radical shift to other mitigation options may come too late to stay within the 2°C target.

Policies that greatly accelerate energy efficiency improvements on both the demand- and supply-side can, if widely applied, reduce the need for net negative emissions and allow more time for a transition to a global economy with radically lower greenhouse gas emissions.

Some assessments, notably the IPCC *Special Report on Renewable Energy Sources and Climate Change Mitigation* and the *Global Energy Assessment* (GEA) emphasize the great importance of accelerating demand-side efficiency and conservation measures for future reductions of greenhouse gas emissions. A headline conclusion of the GEA scenario assessment is that a significantly lower level of global energy demand would make it possible to reach the 2°C and other sustainability targets without relying on a combination of nuclear energy and carbon capture and storage. But it must be emphasized that it would be necessary to greatly accelerate the current rate of energy efficiency improvements, and the feasibilty of doing so has been fully investigated.

5. What are the implications of scenarios that meet the 2°C target, but have higher global emissions in 2020?

Based on a very limited number of studies, it is expected that scenarios with higher global emissions in 2020 are likely to have higher medium- and long-term costs, and – more importantly – pose serious risks of not being feasible in practice.

The estimates of the emissions gap in this and previous reports are based on least cost scenarios which depict the trend in global emissions up to 2100 under the assumption that climate targets are met by the cheapest combination of policies, measures and technologies considered in a particular model.[7] There are now a few published studies on later action scenarios that have taken a different approach. These scenarios also seek to limit greenhouse gas emissions to levels consistent with 2°C, but assume less short-term mitigation and thus higher emissions in the near term. Because of the small number of studies along these lines, the question about the costs and risks of these later action scenarios cannot be conclusively quantified right now.

That being said, it is clear that later action will imply lower near-term mitigation costs. But the increased lock-in of carbon-intensive technologies will lead to significantly higher mitigation costs over the medium- and long-term. In addition, later action will lead to more climate change with greater and more costly impacts, and higher emission levels will eventually have to be brought down by society at a price likely to be higher than current mitigation costs per tonne of greenhouse gas.

Moreover, later action will have a higher risk of failure. For example, later action scenarios are likely to require even higher levels of "net negative emissions" to stay within the 2°C target, and less flexibility for policy makers in choosing technological options. Later action could also require much higher rates of energy efficiency improvement after 2020 than have ever been realised so far, not only in industrialized countries but also in developing countries.

6. Can the gap be bridged by 2020 – and how?

From a technical standpoint, the answer to this question is, yes. The technical potential for reducing emissions by 2020 is estimated to be about 17 ± 3 $GtCO_2e$, at marginal costs[8] below US$ 50-100/ t CO_2e reduced. This is enough to close the gap between BaU emissions and emissions that meet the 2°C or 1.5°C target.

Since the 2011 *Bridging the Emissions Gap* presented these numbers, there have been several new studies of the potential to reduce emissions, confirming that the estimate of the mitigation potential for 2020 of 17 ± 3 $GtCO_2e$ is still valid.

The challenge is the current pace of action. Even if the potential remains the same there is basically one year less to achieve this reduction, implying steeper and more costly actions will be required to potentially bridge the emissions gap by 2020.

At the same time current investments in buildings, transportation systems, factories, and other infrastructure are "locking in" high energy use patterns and associated emissions for decades, limiting future options for abating emissions.

The gap can be narrowed by resolving some immediate climate negotiation issues

Possible actions to narrow the gap include:

- Implementing the more ambitious "conditional" pledges. This would reduce the gap by 2 $GtCO_2e$.
- Minimizing the use of lenient Land Use, Land Use Change and Forestry (LULUCF) credits and surplus emission credits. This would reduce the gap by around 3 $GtCO_2e$.
- Minimizing the use of the surplus Assigned Amounts from the 2008-2012 Kyoto period. This would reduce the gap by 1.8 $GtCO_2e$.
- Avoiding the double-counting of offsets and improving the additionality of CDM projects. This would reduce the gap by up to 1.5 $GtCO_2e$.

Note that these numbers are not directly additive.

7 Some models impose further restrictions on the technologies they take into account.

8 Marginal costs are the costs of the last tonne of equivalent CO_2 removed. The average costs of all the reductions together are much lower.

Policy actions at the national and local level are being implemented in a growing number of countries and have shown to be effective in substantially reducing emissions. Replicating these successful policies and scaling them up would provide a way for countries to go beyond their current pledges and help to close the gap.

Most of these policies are now being carried out primarily for reasons other than climate change mitigation. It is clear, therefore, that countries can contribute to narrowing the emissions gap by enhanced action in line with their own national development priorities.

The following selected policies were reviewed in this report because they have been successful in reducing emissions and show promise in being scaled up nationally and internationally. However, they only represent a few of the many promising policies meriting further consideration:

- In the building sector promising policies include:
  - *(i) building codes* and
  - *(ii) appliance standards.*

  The motivation for these policies has been mostly to reduce residential and private sector energy use and costs and to increase safety.
- In the transport sector – A cluster of successful policies are described by the concept "Avoid-Shift-Improve". These include:
  - *(i) transportation-related land use policies,*
  - *(ii) bus rapid transit,* and
  - *(iii) vehicle performance standards for new light-duty vehicles.*

  The main objectives of transportation-related land use policies have been to increase the proximity of urban residents to their destination, and maximize the efficiency of public transportation, with the aim to reduce the need for private vehicles and their impacts. Meanwhile, bus rapid transit systems have been developed to reduce traffic congestion and urban air pollution, and vehicle performance standards to reduce vehicle energy use and thereby reduce passenger costs and enhance energy security.
- In the forestry sector promising policies include:
  - *(i) protected areas and other command-and-control measures;*
  - *(ii) economic instruments*
  - *(iii) policies affecting drivers and contexts.*

  The impetus for these policies includes the preservation of indigenous cultures, protection of biodiversity and endangered species, and protection of watersheds. The reduction of greenhouse gas emissions is also a main motivating factor in some cases.

While these policies differ substantively, they provide real life examples of how ambitious national or local policy instruments driven by priorities such as stimulating innovation and economic growth, bolstering national energy security or improving public health, can lead to large emission reductions. The potential for scaling up and replicating these policies is large and a number of common factors have been found to realize this potential:

- Successful scale-up requires policy instruments to be tailored to local economic, financial, social and institutional contexts. Codes and standards have shown the greatest success where government-led implementation and enforcement is generally accepted, particularly if market barriers make the use of economic instruments difficult. However, institutional capacity for monitoring and enforcement is also crucial for their effectiveness
- National and local interests, broader than climate considerations, are often key drivers for successful policies. Focus should therefore be on adoption of sound climate policies as an integrated part of comprehensive policy packages that focus on multiple benefits and support national development goals.
- Successful national and local policies typically combine market-based instruments with regulatory approaches.
- Continuously increasing the stringency of policies, such as codes, standards, labels and zoning, is central for their sustained effectiveness in reducing emissions and sends important long term signals to markets.

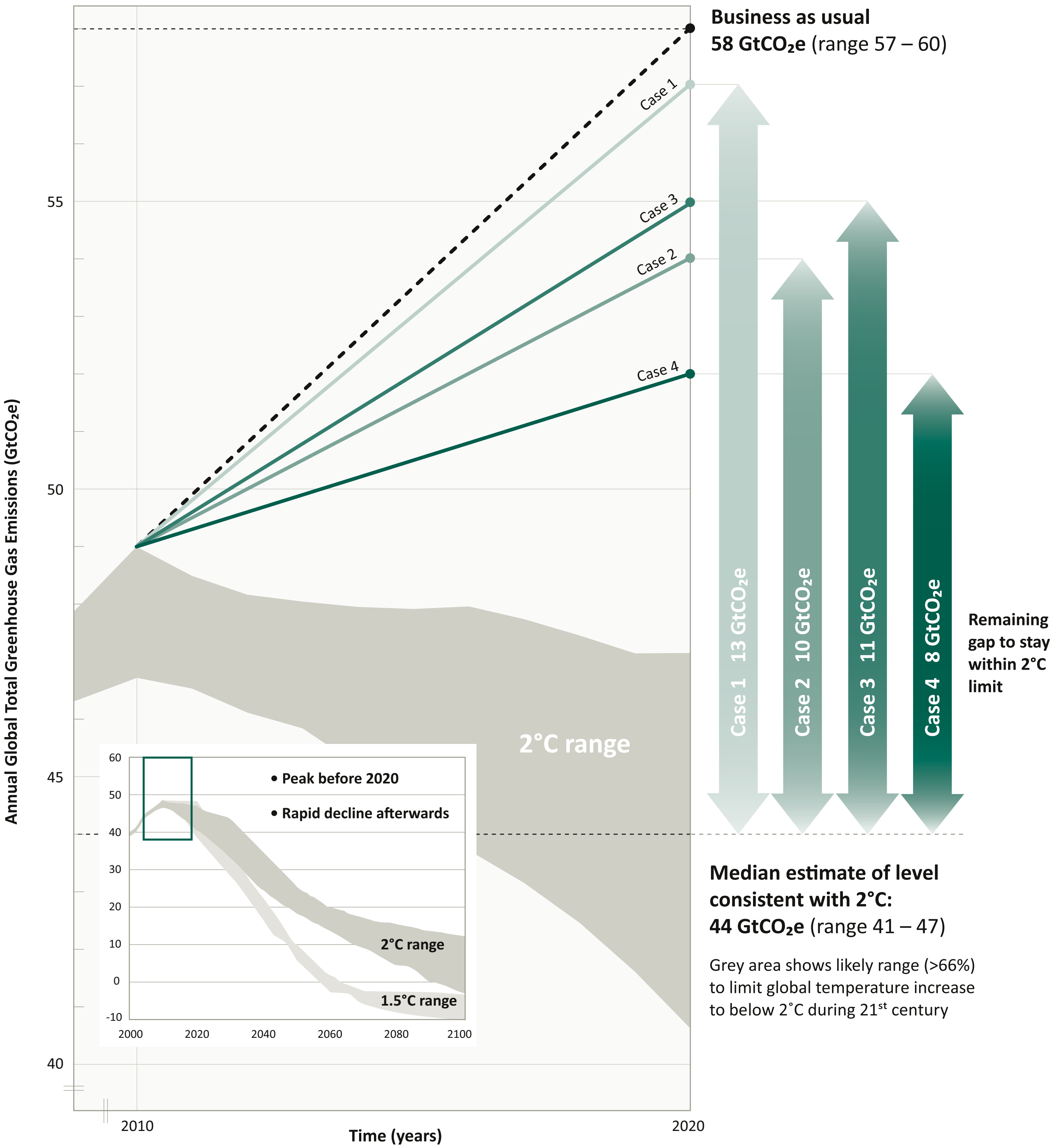
Summing up

This report shows that the estimated emissions gap in 2020 for a "likely" chance of staying below the 2°C target is large, but it is still technically possible to close this gap through concerted and rapid action.

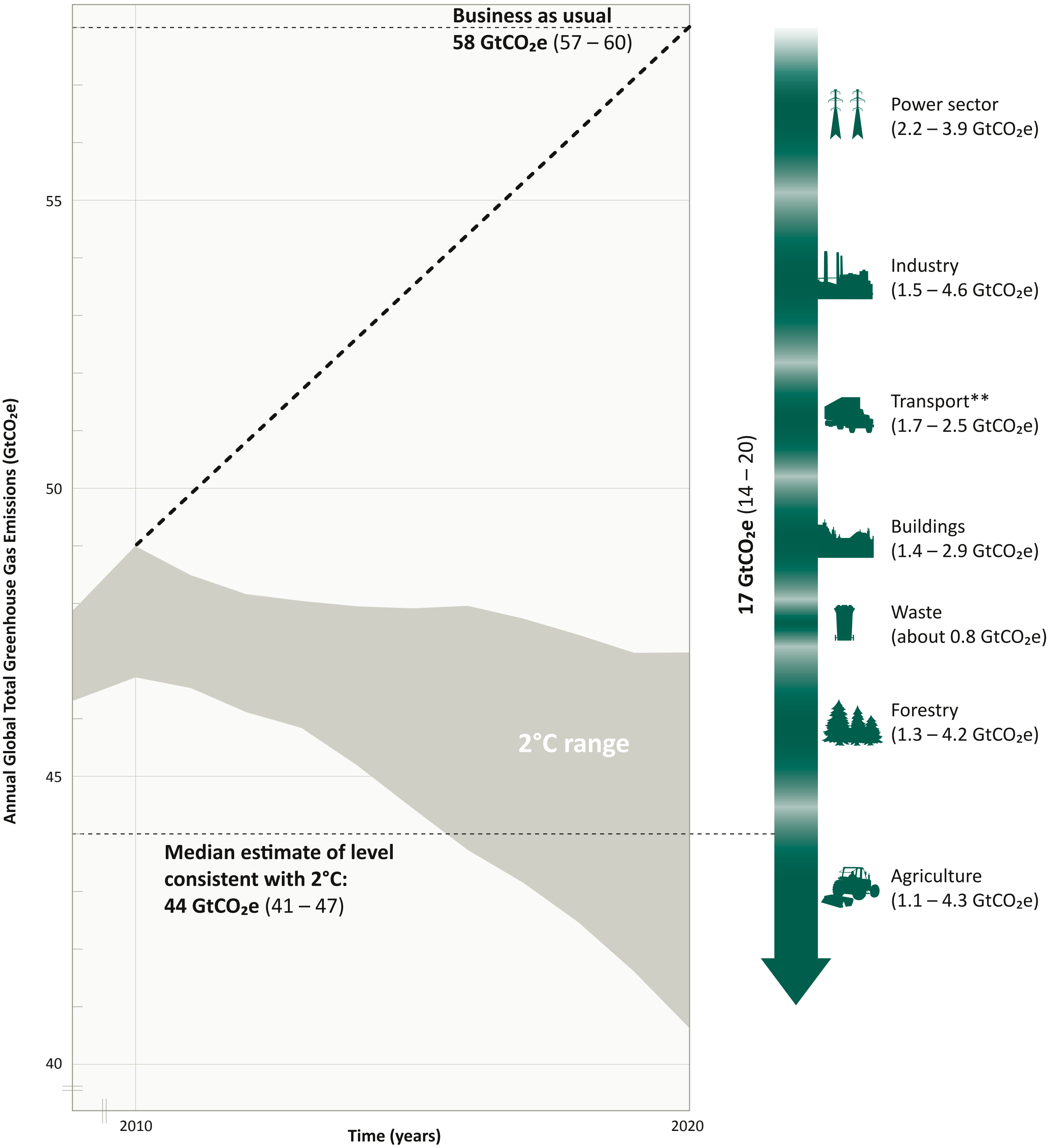
The report highlights concrete, internationally-coordinated ways to do so: by increasing current national reduction pledges to the higher end of their range, by bringing more ambitious pledges to the table, and by adopting strict rules of accounting.

The gap can also be closed by swift and comprehensive action to scale up a wide range of tried-and-true policy actions. These are actions that have worked around the world and in many different sectors, and which are not only beneficial to climate protection, but also satisfy a great variety of other local and national priorities.

The emissions gap



How to bridge the gap: results from sectoral policy analysis*



*based on results from Bridging the Emissions Gap Report 2011
**including shipping and aviation

Chapter 1:

Introduction

At the Conference of Parties of the United Nations Framework Convention on Climate Change (UNFCCC) in Durban in December, 2011, the international community took an important step towards enhancing action on climate change by agreeing to the Durban Platform. Countries decided to adopt by 2015 "a protocol, another legal instrument or an agreed outcome with legal force under the Convention applicable to all Parties", to come into effect and be implemented beginning in 2020.

At the same time, countries noted "with grave concern the significant gap between the aggregate effect of Parties' mitigation pledges in terms of global annual emissions of greenhouse gases by 2020 and aggregate emission pathways consistent with having a "likely" chance of holding the increase in global average temperature below 2°C or 1.5°C above pre-industrial levels" (UNFCCC, 2011).

The pledges and the temperature targets referred to in this paragraph were formally recognized in the 2010 Cancún Agreements (UNFCCC, 2010), and referred to one year earlier in the Copenhagen Accord (UNFCCC, 2009).

With the agreement of the international community to a temperature target and to pledges for emission reductions by 2020, a central question arises: "Will there be a gap in 2020 between emissions expected after the implementation of pledges and the level consistent with the 2°C target?" The answer to this question provided by the UNEP *Emissions Gap Report*, published for the Cancún climate summit in December 2010, was a clear "yes". The report clearly documented a substantial gap, even if pledges were fully implemented.

After publishing the first *Emissions Gap Report,* UNEP was requested by policymakers to prepare a follow-up report which not only updated the emissions gap estimates, but also addressed a subsequent question: "can the emissions gap be bridged?" In response, the *Bridging the Emissions Gap Report* (UNEP, 2011) was released in November, 2011, before the Durban climate summit. This second report concluded that technical potential for reducing emissions by 2020 exists, and that this potential is large enough to bridge the emissions gap. The report also noted that no significant technical or financial breakthroughs are required to realise this potential.

After the *Bridging the Emissions Gap Report* was published, many Parties to the UNFCCC requested an annual or semi-annual *Emissions Gap Report* as an input to the global climate negotiations, and UNEP has subsequently made a commitment to prepare such a report in 2012 and at least over the next two to three years.

For this third report, UNEP in collaboration with the European Climate Foundation convened 55 scientists and experts from 43 scientific groups across 22 countries. The report specifically covers the following:

- An update of global greenhouse gas emission estimates, based on a number of different authoritative scientific sources;
- An overview of national emission levels, both current (2010) and projected (2020), consistent with current pledges and other commitments;
- An estimate of the level of global emissions consistent with the two degree target in 2020, 2030 and 2050;
- An update of the assessment of the emissions gap for 2020;
- A review of selected examples of the rapid progress being made in different parts of the world to implement policies already leading to substantial emission reductions. These policies could contribute significantly to narrowing the gap if they are scaled up and replicated in other countries.

With the combination of analytical updates and new focal issues, this years' report continues to provide a wealth of information and insights on the emissions gap and how it can be bridged in order to steer the world towards long-term climate protection. The report underlines the challenge resulting from the current pace of mitigation efforts and notes that, even if the potential to bridge the gap can still realised at the moment, there is basically one year less to achieve this reduction, implying that steeper and more costly actions might be required to bridge the gap.

Chapter 2:

Current and Projected Greenhouse Gas Emissions

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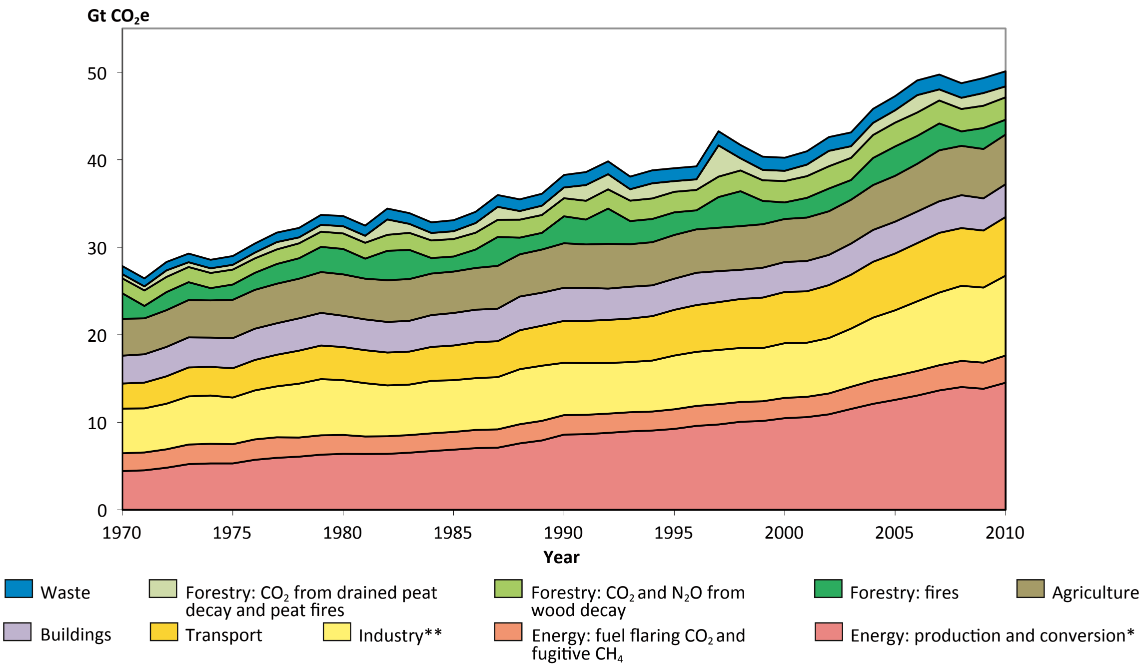
2.1 Introduction

This chapter gives an overview of current and projected global emission estimates, to frame the analysis of both the emissions gap and of potential measures to close the gap. The chapter begins with an overview and analysis of the trend, size and composition of current global greenhouse gas emissions. This is followed by an analysis of expected global emissions in 2020 under a business-as-usual scenario as well as under four scenario cases based on assumptions regarding the implementation of countries' emission reduction pledges. Finally, updated information on country pledges, along with the most current information on national greenhouse gas emissions, is provided. This section also compares current and projected emissions and emission intensities of the G20 countries, taking the EU as a group. Emissions are measured in units of carbon dioxide equivalent (CO_2e) for the gases covered by the Kyoto Protocol[9] and reported under the UNFCCC (UNFCCC, 2002).

9 Unless otherwise stated, all emissions in this report refer to $GtCO_2e$ (gigatonnes or billion tonnes of carbon dioxide equivalent) – the global warming potential (GWP)-weighted sum of the greenhouse gases covered by the Kyoto Protocol, that is CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. Similarly, unless otherwise stated, data include emissions from land use, land-use change and forestry (LULUCF).



* Power generation, refineries, coke ovens, etc.

** Including non-combustion CO_2 from limestone use and from non-energy use of fuels and N_2O from chemicals production.

Figure 2.1. Trend in global greenhouse gas emissions 1970-2010 by sector (using Global Warming Potential values as used for UNFCCC/Kyoto Protocol reporting). This graph shows emissions of 50.1 $GtCO_2e$ in 2010, as derived from bottom-up emission inventories (see Section 2.2.1). An alternative estimate of 2010 emissions of 49 $GtCO_2e$ from the modeling groups is used elsewhere in the report. *Source: JRC/PBL (2012) (EDGAR 4.2 FT2010)*

2.2 Current and projected global emissions

2.2.1 Current global emissions

Total greenhouse gas emissions in 2010 are estimated from bottom-up emission inventories to be 50.1 $GtCO_2e$ (with a 95% uncertainty range of between 45.6 and 54.6 $GtCO_2e$)[10] (JRC/PBL, 2012).

An alternative estimate of 49 $GtCO_2e$ (range 48-50) for 2010 is provided by the modeling groups. This figure falls well within the uncertainty range given in the previous paragraph. The figure of 49 $GtCO_2e$ is used throughout the rest of the report since most of the report has to do with modeling analyses.

Figure 2.1 shows the trend in global and sectoral greenhouse gas emissions from 1970 to 2010, illustrating the increase in global emissions over this period as well as the growth of energy production and conversion in the share of total emissions. In the period 2009-2010 emissions increased by 0.8 $GtCO_2e$ or 1.6% when including LULUCF-related CO_2 emissions (emissions increased by about 3.5% when excluding LULUCF). Compared to 1990, global emissions including LULUCF have increased by about 30%. In the period 2000-2010 the increase in global emissions including LULUCF was around 20% (JRC/PBL, 2012).

Figure 2.2a illustrates the break-down of global greenhouse gas emissions in 2010 by main sectors, while Figure 2.2b illustrates the emissions by main sectors and gas types.

Trends for different gases are as follows: global CO_2 emissions from fossil fuel use and cement production declined in 2009 due to the recession, but increased sharply afterwards in 2010 and 2011. One study reports a 1% decline in 2009, 5% increase in 2010 and again a 3% increase in 2011, compared to the previous year, reaching an all-time high of 34 Gt (JRC/PBL, 2012; Olivier et al., 2012). Global emissions from forestry and land use decreased in 2010 by about 15%. Global emissions of CH_4 and N_2O increased in 2010 by about 0.5%, while emissions of fluorinated greenhouse gases increased by about 7% and are now contributing 2% to global total greenhouse gas emissions (see Figure 2.2b). CH_4 and N_2O emissions contributed 16% and 6% respectively to total CO_2-equivalent emissions in 2010. At the country level, however, these shares can be very different. Readers should keep in mind that these shares and trends are associated with some uncertainty (see on-line Appendix 1 for more information).

The consolidated estimate of total greenhouse gas emissions with its uncertainty range was prepared using global greenhouse gas emission inventories from various sources (for CO_2 from IEA, EDGAR, CDIAC, EIA and national submissions to the UNFCCC) and updated estimates inferred from atmospheric measurements.

2.2.2 Projected global "Business-as-usual " emissions in 2020

Global greenhouse gas emissions are estimated to be 58 $GtCO_2e$ (range 57 to 60 $GtCO_2e$) in 2020 under business-as-usual (BaU) conditions, which is about 2 $GtCO_2e$ higher than the BaU estimated in the Bridging the Emissions Gap Report (UNEP, 2011). BaU emissions were derived based on estimates from seven modelling groups[11] that have analysed a selection of emission reduction proposals by countries and have updated their analysis recently. This data set is used in the remainder of this chapter.

The range of BaU estimates is in part a result of modelling groups taking different, equally valid, approaches to calculate "business-as-usual ". Some of the seven research groups used the respective BaU scenarios that the countries provided together with their pledge. Other groups updated the BaU for some countries based on new economic projections without taking into account climate policies. Both cases represent a scenario without the actions under the pledges. Other modelling groups considered some national policies that were implemented after their pledge was made. In this case, the BaU represents a likely pathway given currently implemented policies. Constructing a complete scenario of this kind for all countries was not possible from the available studies. Future Gap reports will aim to differentiate between these two cases, as the difference of these two assumptions is likely to become bigger in the future as more policies are implemented.

The reason for the increase in estimated BaU emissions compared to those estimated in last year's report is that some modelling groups moved their start year from 2005 to a more recent date and because economic growth in emerging economies between 2005 and 2010 was higher than expected in 2005.

2.3 National emission reduction pledges and expected global emissions in 2020 as a result of the pledges

Since November 2011, no major economy has significantly changed its emission reduction pledge under the UNFCCC. Some countries have clarified their assumptions and specified the methods by which they would like emissions accounted for. For example, Belarus expressed their 2020 target as a single 8% reduction compared to 1990 levels rather than the range 5-10%, and Kazakhstan changed their reference year from 1992 to 1990. South Africa and Mexico included a range instead of a fixed value for their BaU in 2020, which changes their BaU-related pledges. South Korea updated their BaU emissions in 2020 downwards, which reduces estimated emission levels after implementing its pledge. These changes may be significant for the countries in question but are minor at the global level (in aggregate, they are smaller than 1 $GtCO_2e$ in 2020).

The projection of global emissions in 2020 as a result of the pledges depends on whether the pledges are implemented and on the accounting rules for these pledges:

- A "conditional" pledge depends on factors such as the ability of a national legislature to enact necessary laws, action from other countries, or the provision of finance or technical support. Some countries did not

10 This estimate includes CO_2 emissions from fossil fuel use and emissions of methane (CH_4), nitrous oxide (N_2O), and fluorinated gases (HFCs, PFCs and SF_6), as well as CO_2 emissions from forest and peat fires and related biomass decay.

11 The modelling groups are: Climate Action Tracker by Ecofys (Climate Action Tracker, 2010); Climate Analytics and Potsdam Institute for Climate Impact Research, PIK, www.climateactiontracker.org; Climate Interactive (C-ROADS), www.climateinteractive.org/scoreboard; Fondazione Eni Enrico Mattei (FEEM), http://www.feem.it/; Grantham Research Institute, London School of Economics; OECD Environmental Outlook to 2050 (OECD 2012); PBL Netherlands, www.pbl.nl/en and UNEP Risoe Centre (UNEP 2012).

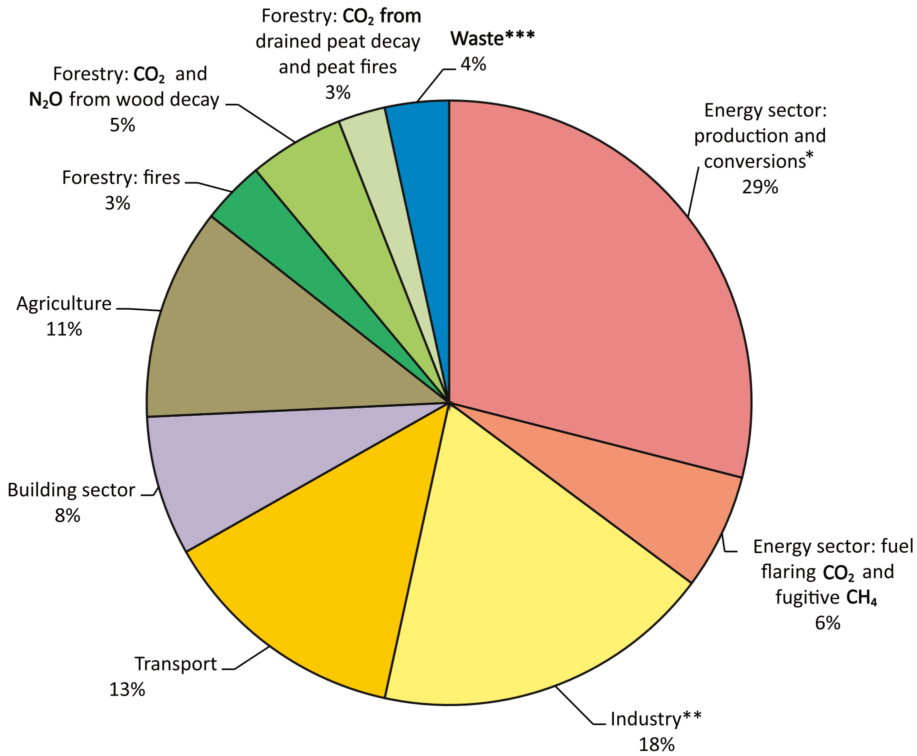


Figure 2.2a. Shares of sources of global greenhouse gas emissions in 2010 by main sector (in CO_2e using GWP values as used for UNFCCC/Kyoto Protocol reporting). *Source: JRC/PBL (2012) (EDGAR 4.2 FT2010)*

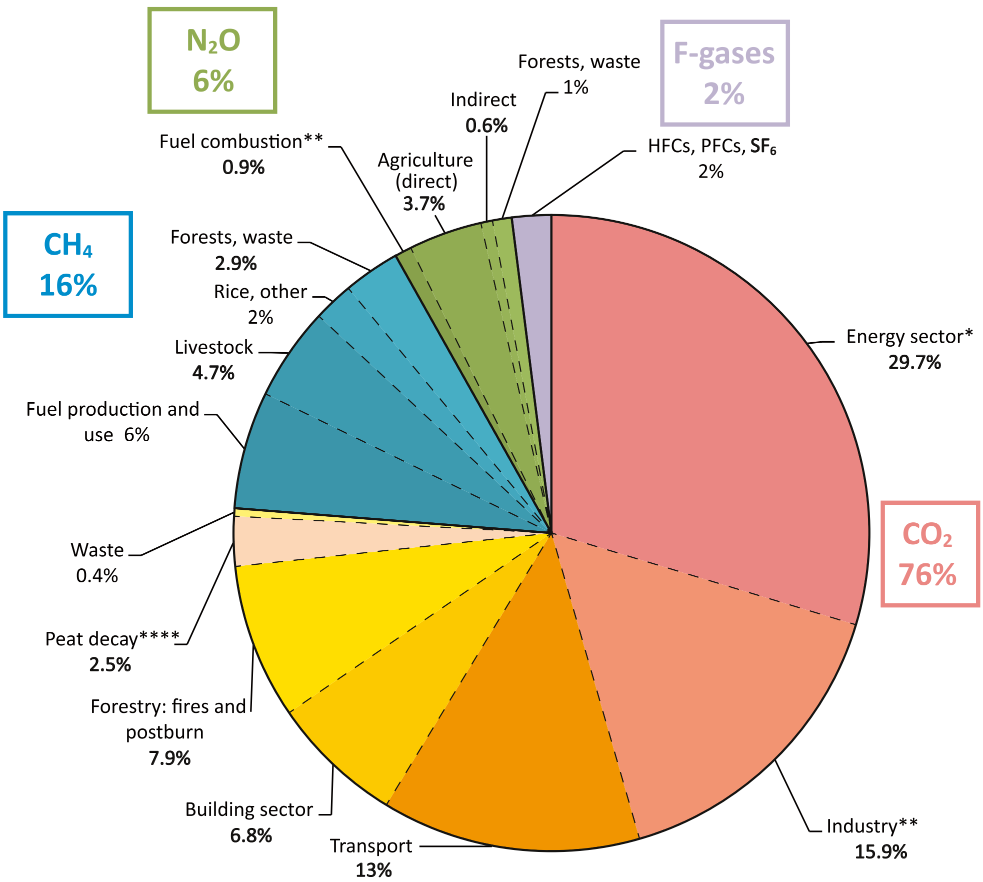


Figure 2.2b. Shares of sources of global greenhouse gas emissions in 2010 by main sector and gas type (in CO_2e using GWP values as used for UNFCCC/Kyoto Protocol reporting). *Source: JRC/PBL (2012) (EDGAR 4.2 FT2010)*

* Power generation, refineries, coke ovens.
** Including non-combustion CO_2 from limestone use and from non-energy use of fuels and N_2O from chemicals production.
*** Including wastewater.
**** Including peat fires.

attach conditions to their pledge, described here as an "unconditional" pledge.

- International rules on how emission reductions are to be measured after the first commitment period of the Kyoto Protocol have not yet been defined. Accounting rules for emissions from land use, land-use change and forestry (LULUCF) for Annex I countries have now been agreed for a second commitment period under the Kyoto Protocol (Grassi, 2012; UNFCCC, 2012a). However, accounting rules for emissions from developed countries that are not participating in the second commitment period of the Kyoto Protocol (e.g. USA and perhaps Russia, Japan, Canada), as well as rules for non-Annex I countries, have not been agreed upon.
- In addition, rules have not been agreed for using surplus emissions credits, which will occur when countries' actual emissions are below their emission reduction targets of the first commitment period of the Kyoto Protocol. These rules apply only to countries participating in a second commitment period of the Kyoto Protocol. The emission reduction targets for other countries is more uncertain under these rules.
- Finally, there is potential "double counting", where emission reductions in developing countries that are supported by developed countries through offsets (for example, using the Clean Development Mechanism) are counted towards meeting the pledges of both countries. These reductions occur only once and should be accounted for only towards the developed or the developing country, not to both. Rules on how to treat such potential double counting have not been agreed to, nor have countries agreed to avoid double counting. For example, some countries have stated that emission reductions sold to other jurisdictions will still be considered as meeting their pledge as well.

2.3.1 Four "cases" of expected emissions in 2020

In line with the 2010 Emissions Gap Report and Bridging the Emissions Gap Report (UNEP, 2010; 2011), this update describes four scenario cases of emissions in 2020, based on whether pledges are conditional, or not; and on whether accounting rules are strict or more lenient (see Figure 2.3). We define "strict" rules to mean that allowances from LULUCF accounting and surplus emission credits will not be counted towards the emission reduction pledges. Under "lenient" rules, these allowances can be counted as part of countries meeting their pledges. New in this year's report compared to earlier reports is that the lenient case also includes an estimate for potential "double counting" of reductions. This additional element increases the upper limit of pledged emissions in the lenient case by 1.5 $GtCO_2e$.

Case 1 – "Unconditional pledges, lenient rules"

If countries implement their lower-ambition pledges and are subject to "lenient" accounting rules, then the median estimate of annual greenhouse gas emissions in 2020 is 57 $GtCO_2e$, within a range of 56-57[12] $GtCO_2e$.

12 Ranges in this report are 20th – 80th percentile unless stated otherwise (see glossary for definition of 20th – 80th percentile).

Case 2 – "Unconditional pledges, strict rules"

This case occurs if countries keep to their lower-ambition pledges, but are subject to "strict" accounting rules. In this case, the median estimate of emissions in 2020 is 54 $GtCO_2e$, within a range of 54-55 $GtCO_2e$.

Case 3 – "Conditional pledges, lenient rules"

Some countries offered to be more ambitious with their pledges, but linked that to various conditions described previously. If the more ambitious conditional pledges are taken into account, but accounting rules are "lenient", median estimates of emissions in 2020 are 55 $GtCO_2e$ within a range of 54-56 $GtCO_2e$.

Case 4 – "Conditional pledges, strict rules"

If countries adopt higher-ambition pledges and are also subject to "strict" accounting rules, the median estimate of emissions in 2020 is 52 $GtCO_2e$, within a range of 51-52 $GtCO_2e$.

2.3.2 Land use, land-use change and forestry (LULUCF): an update

Under the Kyoto Protocol, developed countries (Annex I Parties) may receive credits or debits from LULUCF activities dependent on a series of complex LULUCF accounting rules that contribute to the achievement of their individual emission reduction targets. In the Durban climate negotiations, countries agreed to new LULUCF accounting rules for countries participating in the second commitment period (CP2) of the Kyoto Protocol. One study (Grassi et al., 2012) found that the potential contribution of LULUCF accounting under these new rules is relatively modest (a difference of up to about 2% of 1990 emissions between strict and lenient accounting) for the Annex I Parties that joined the first commitment period (2008-2012) of the Kyoto Protocol as a whole. We have used a value of 0.3 $GtCO_2e$ in the lenient case, assuming that all Annex I countries adopt the new rules. This value may be an underestimate, given that Russia, USA, Canada and Japan may adopt different accounting practices outside the Kyoto Protocol.

2.3.3 Surplus Assigned Amount Units (AAUs): an update

Countries with actual emission levels below their emission target at the end of the first commitment period of the Kyoto Protocol will have surplus Assigned Amount Units (AAUs) or other emission credits. Under the Kyoto Protocol, these surplus credits may effectively be carried from the first to a following commitment period. In the climate negotiations, various options for addressing carry-over and sale of surplus AAUs have been put forward. One study (den Elzen et al., 2012a) analysed the effect of some of these options on the reduction pledges for 2020, taking into account the estimated credits from the Clean Development Mechanism, Joint Implementation projects, and land-use activities for the first commitment period. Under the assumption of gradually increasing usage of first commitment period surplus units between now and 2020, and a maximum carry-over of about 14 $GtCO_2e$ [13], effective target levels by 2020

13 Point Carbon (2012) found a similar estimate of net AAU surplus of about 13 $GtCO_2e$.

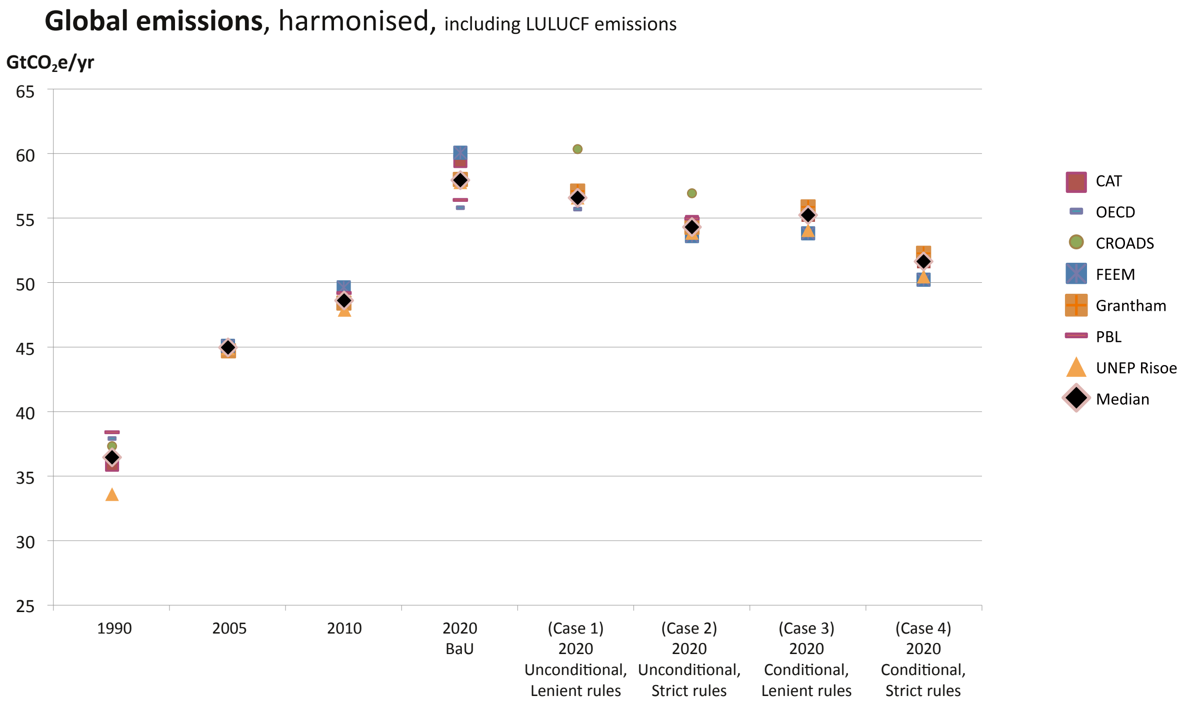


Figure 2.3. Emissions in 2020 under BaU and as a result of pledges under four cases. Note: to ensure a consistent comparison of the pathways and pledges we have harmonized the data to the same 2005 emissions of 45 $GtCO_2e$ (except Grantham where values for 2005 were not collected).

will be reduced by between 0 and 3.5 $GtCO_2e$, depending on the accounting rules for surplus units and the willingness of Parties to purchase them. Using carry-over of surplus units at equal amounts each year would halve this impact. Russia potentially has a large surplus from the first commitment period of the Kyoto Protocol, but has indicated it will not join a second commitment period and has not submitted a target under the Kyoto Protocol[14], which would mean that these allowances would not be available to other countries. Excluding Russia from the analysis, total surplus units by 2020 are projected to vary between 0 and 1.8 $GtCO_2e$ (den Elzen et al., 2012b). Accordingly, we have used the estimate of 1.8 $GtCO_2e$ in the lenient case, to show the maximum impact that would occur if all surplus credits were purchased by countries with pledges that do require emission reductions, displacing mitigation action in those countries.

2.3.4 The potential impact of use of offsets

The potential effect of the use of offsets can only be calculated roughly. A recent study (Erickson et al., 2011) estimates offsets to account for as much as 1.6 $GtCO_2e$. In addition, there is a risk that more offset credits are generated than emissions are actually reduced. Project activities need to be "additional" to the expected development without the project. Such comparison with a hypothetical case is difficult and there is indeed evidence that a significant share of CDM projects is not additional (Haya, 2009). Assuming this share to be 25% by 2020, we estimate that up to 0.4 $GtCO_2e$ of offsets could be non-additional, raising the total estimate of the magnitude of offsets to 2.0 $GtCO_2e$. However, the effects of LULUCF accounting, surplus allowances, and use of offsets are only additive as long as there is demand for them, that is, as long as Annex I countries need to reduce emissions further. Hence, we assumed that the use of offsets (double counting and non-additionality) could lead to an increase of the upper limit of allowed emission in the order of 1.5 $GtCO_2e$ in the lenient case at the global level.

14 http://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/tableqelrcs_fromparties_for_website_posting_17aug2012_cln.pdf

2.3.5 Updated BaUs and updates on the use of offsets increases pledge case emissions

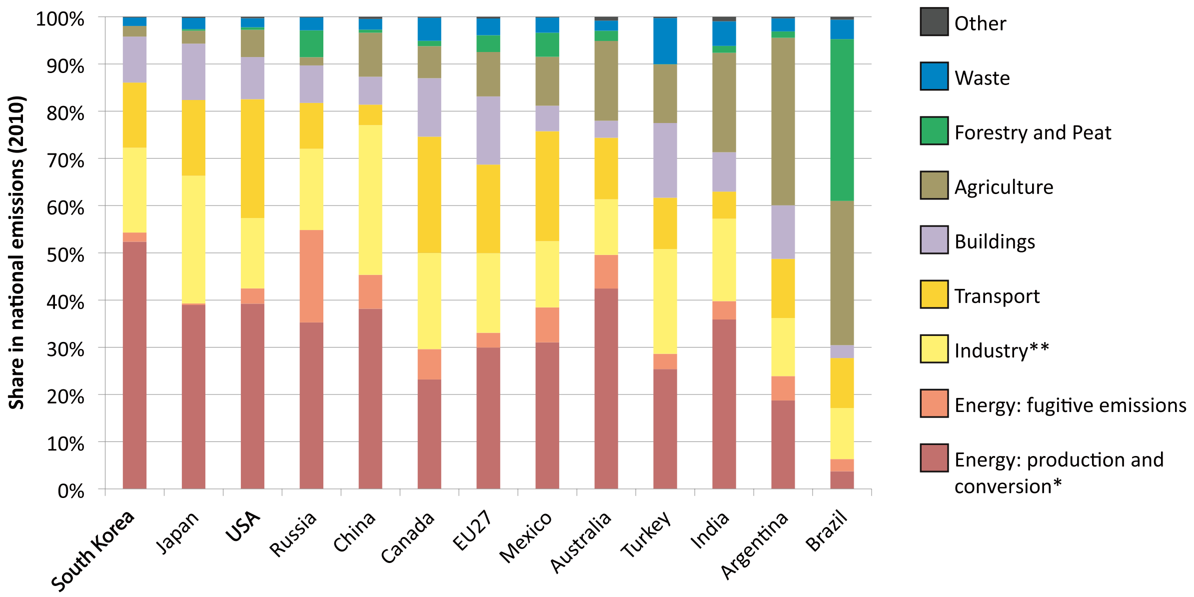
The updated emissions for the four pledge cases are around 1 to 2 $GtCO_2e$ higher compared to last year's Bridging the Emissions Gap Report (UNEP, 2011), which is due to various factors. For example, this year's report only includes recently updated studies in the analysis. These studies include the high recent and projected emissions growth following recent global macroeconomic trends. The older studies that are not included in this year's assessment had lower economic growth. The additional effects of the use of offsets of 1.5 $GtCO_2e$ in the lenient cases were also included. This has a limited effect on case 1 (lenient, unconditional) because in this case the required reductions by Annex I countries as a group are already quite limited. The use of offsets, however, has enlarged the difference between case 3 (lenient, conditional) and case 4 (strict, conditional) to 3 $GtCO_2e$.

2.4 Current and projected national emissions

This section provides a detailed overview of the pledges submitted by countries, along with information on their current greenhouse gas emissions. In addition, it compares the emissions and pledges of G20 countries, treating the European Union (EU27) as a group. The figures put the pledges in perspective with historical trends and on a unit of Gross Domestic Product (GDP) and per capita basis.

2.4.1 Sectoral shares of emissions influence the formulation of national pledges

The sectoral shares of national greenhouse gas emissions vary substantially among countries (see Figure 2.4). Countries usually take into account this sectoral distribution in the



* Power generation, refineries, coke ovens.

** Including non-combustion CO_2 from limestone use and from non-energy use of fuels and N_2O from chemicals production.

Figure 2.4. Sectoral shares of national greenhouse gas emissions in 2010 for countries included in the G20 with a pledge, taking European Union as a group. *Source: JRC/PBL (2012); EDGAR 4.2 FT2010.*

formulation of their pledges. In general, developed countries' emissions are dominated by energy-related fuel combustion, accounting for 65% to 85% of the national total[15]. For these countries energy efficiency and low carbon energy sources are major mitigation options. Other countries' emissions profiles are dominated by agriculture and forestry, making reductions in these sectors more important. In addition, they have the opportunity in their development choices to avoid the high use of fossil fuels characterising many developed countries. Some countries have unique emissions profiles, with Russia having a high share of fugitive emissions from natural gas production and Brazil with a very high share from forestry.

2.4.2 An overview of pledges and current greenhouse gas emissions by country

Figure 2.5 provides a map of pledges by country. The countries shown on the map have been grouped into three categories: those that have made an emission reduction proposal for 2020 defined in terms of greenhouse gas emissions; countries that have submitted actions, e.g.,

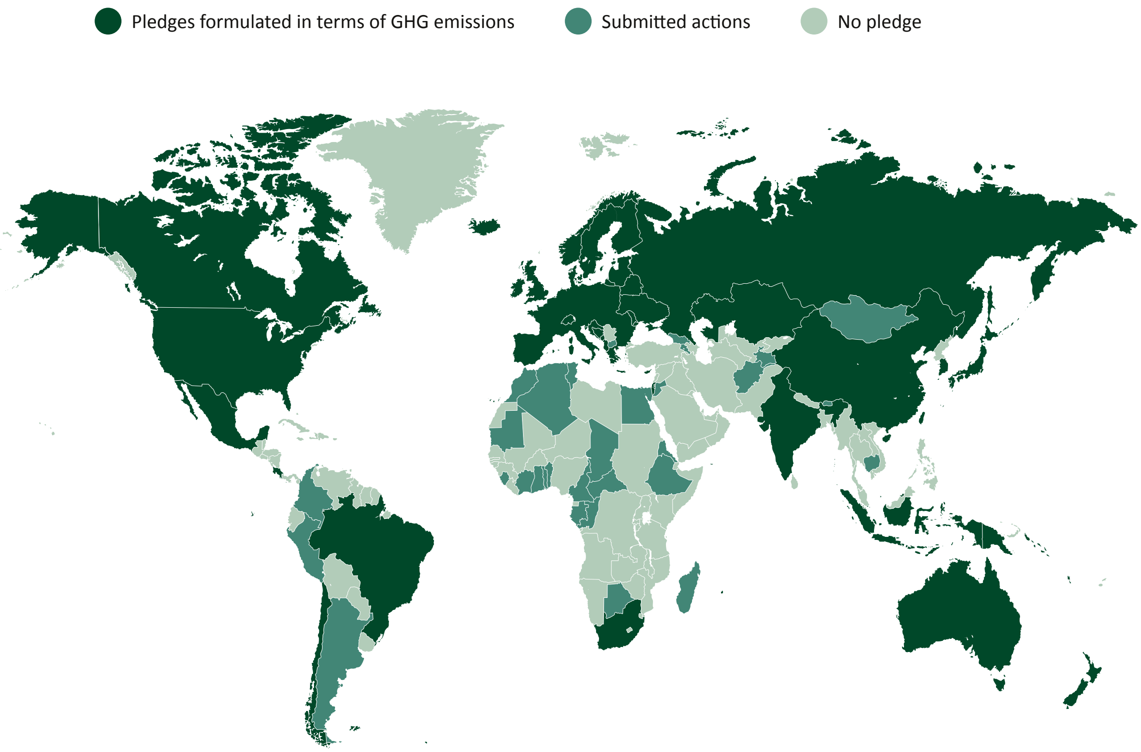


Figure 2.5. Pledge map: Countries classified according to type of pledge[16]

15 Notable exceptions are Iceland (9%), New Zealand (45%) and Finland (50%).

16 Current international borders

energy targets or proposed projects; and finally, countries that have not made pledges.

Table 2.1 provides an overview of the pledges, unconditional and conditional, submitted by countries under the Copenhagen Accord and the Cancún Agreements. Included are those pledges that are formulated in terms of greenhouse gas emissions. Details of the evaluation for the G20 countries are included in the on-line Appendix 2. For each country, the table gives information on current emissions and share of global emissions. The table shows the classification of pledges as used in this report. It should be noted that the pledges are not directly comparable. The table illustrates the potential significance of the pledges in reducing global emissions: countries listed here account for around 80% of global emissions (including LULUCF emissions) and include major emitters. Only these pledges are used to calculate the emission levels of cases 1 to 4.

Table 2.1. Pledges (unconditional and conditional) as interpreted for this report, current emissions and share of global emissions for countries that formulated pledges in terms of greenhouse gas emissions (countries presented in alphabetical order, current emissions rounded to 1 Mt, share of global emissions indicated with two significant digits).

Country	Unconditional pledge	Conditional pledge	Current emissions ($MtCO_2e$ 2010)	Share of global emissions (% world total 2010)
Antigua and Barbuda	Reduce emissions by 25% below 1990 level by 2020	-	1	0.0010
Australia	Reduce emissions by 5% below 2000 level by 2020	Reduce emissions by 25% below 2000 level by 2020	629	1.3
Belarus	Reduce emissions by 8% below 1990 level by 2020	-	150	0.30
Brazil	Reduce emissions by 36.1% to 38.9% below BaU by 2020	-	1621	3.2
Canada	No unconditional pledge, BaU emissions growth assumed	Reduce emissions by 17% below 2005 level by 2020	728	1.5
Chile	20% reduction below the BaU in 2020, as projected from 2007	-	107	0.21
China	Lower CO_2 emissions per unit of GDP by 40-45% by 2020 compared to the 2005 level; increase share of non-fossil fuels in primary energy consumption to around 15% by 2020; increase forest coverage by 40 million hectares and forest stock volume by 1.3 billion cubic meters by 2020 from 2005 levels	-	11182	22
Costa Rica	None, assumed to follow BaU trajectory	Carbon neutrality by 2021	11	0.022
Croatia	Reduce emissions by 5% below 1990 level by 2020	-	31	0.062
EU27	Reduce emissions by 20% below 1990 level by 2020	Reduce emissions by 30% below 1990 level by 2020	4999	10
Iceland	Reduce emissions by 15% below 1990 level by 2020	Reduce emissions by 30% below 1990 level by 2020	23	0.046
India	Reduce emission intensity of GDP by 20 to 25% by 2020 in comparison to the 2005 level	-	2692	5.4
Indonesia	Reduce emissions by 26% on BaU by 2020	Reduce emissions by 41% on BaU by 2020 (government announcement, not an official pledge)[17]	1946	3.9
Israel	Reduce emissions by 20% on BaU by 2020	-	79	0.16
Japan	No unconditional pledge, BaU emissions growth assumed	Reduce emissions by 25% below 1990 level by 2020	1379	2.8
Kazakhstan	Reduce emissions by 15% below 1990 level by 2020	-	318	0.63

17 Indonesia's high case commitment of 41% is not included in the Copenhagen Accord but was announced prior to COP15 by the President of Indonesia. The impact of this pledge is included in the two conditional pledge cases presented in this Chapter.

Table 2.1. Continued

Country	Unconditional pledge	Conditional pledge	Current emissions ($MtCO_2e$ 2010)	Share of global emissions (% world total 2010)
Korea (South)	Reduce emissions by 30% below BaU by 2020	-	647	1.3
Liechtenstein	Mirrors the EU pledge	Mirrors the EU pledge	Not available	Not available
Maldives	None, assumed to follow BaU trajectory	Reduce net emissions to zero by 2020	1	0.0015
Marshall Islands	Reduce emissions by 40% below 2009 levels by 2020	-	Not available	Not available
Mexico	Emissions reductions through to 2012 in line with Special Climate Change Programme. Estimated to deliver 51$MtCO_2e$ reduction on BaU in 2020	Reduce emissions by 30% below business-as- usual in 2020	661	1.3
Moldova	Reduce emissions by 25% below 1990 by 2020	-	11	0.023
Monaco	Reduce emissions by 30% below 1990 level by 2020	-	Not available	Not available
Montenegro	Reduce emissions by 20% below 1990 by 2020	-	Not available	Not available
New Zealand	Reduce emissions by 10% below 1990 level by 2020	Reduce emissions by 20% below 1990 level by 2020	80	0.16
Norway	Reduce emissions by 30% below 1990 level by 2020	Reduce emissions by 40% below 1990 level by 2020	67	0.13
Papua New Guinea	Reduce emissions by at least 50% below BaU by 2030	-	43	0.085
Russian Federation	Reduce emissions by 15% below 1990 level by 2020	Reduce emissions by 25% below 1990 level by 2020	2510	5.0
Singapore	None, assumed to follow BaU trajectory	Reduce emissions by 16% below BaU by 2020	50	0.10
South Africa	None, assumed to follow BaU trajectory	Reduce emissions by 34% below BaU by 2020	422	0.84
Switzerland	Mirrors the EU pledge	Mirrors the EU pledge	57	0.12
Ukraine	Reduce emissions by 20% below 1990 level by 2020	-	397	0.79
United States of America	No unconditional pledge, BaU emissions growth assumed	Reduce emissions by 17% below 2005 level by 2020	6715	13

Source: Country pledge information from UNFCCC (2012b), data on current emissions and their share of global emissions including LULUCF from JRC/PBL (2012) (EDGAR 4.2 FT2010), http://edgar.jrc.ec.europa.eu/overview.php

Table 2.2 provides an overview of the current emissions and share of global emissions of countries not listed in Table 2.1 but which have submitted policy-, sectoral-, and project-level actions. These pledges are not included in cases 1 to 4. Table 2.3 provides an overview of countries without a pledge. The total share of global emissions of the countries included in Table 2.2 and Table 2.3 is around 20%.

Table 2.2. Current emissions and share of global emissions of countries that have submitted policy-, sectoral-, and project- level actions (not formulated in terms of greenhouse gas emissions). Countries presented in alphabetical order, current emissions rounded to 1 Mt, share of global emissions indicated with two significant digits.

Country	Current emissions ($MtCO_2e$ 2010)	Share of global emissions (% world total 2010)
Afghanistan	18	0.035
Algeria	169	0.34
Argentina	315	0.63
Armenia	11	0.023
Benin	47	0.093
Bhutan	9	0.019

***Table 2.2**. Continued*

Country	Current emissions ($MtCO_2e$ 2010)	Share of global emissions (% world total 2010)
Botswana	12	0.023
Cambodia	192	0.38
Cameroon	82	0.16
Central African Republic	512	1.0
Chad	33	0.065
Colombia	187	0.37
Congo, Democratic Republic of	1113	2.2
Côte d'Ivoire	165	0.33
Egypt	276	0.55
Eritrea	5	0.010
Ethiopia	110	0.22
Gabon	22	0.043
Georgia	13	0.026
Ghana	86	0.17
Jordan	25	0.049
Macedonia	12	0.024
Madagascar	43	0.086
Mauritania	12	0.023
Mauritius	3	0.0067
Mongolia	70	0.14
Morocco	78	0.16
Peru	76	0.15
San Marino	Not available	Not available
Sierra Leone	10	0.020
Tajikistan	15	0.029
Togo	23	0.047
Tunisia	38	0.08

Source: Country information from UNFCCC (UNFCCC, 2011), data on current emissions and their share of global emissions including LULUCF from JRC/PBL (2012) (EDGAR 4.2 FT2010): http://edgar.jrc.ec.europa.eu/overview.php

Table 2.3 Current emissions and share of global emissions (alphabetical order) of countries with no pledges with shares of global emissions larger than 0.1% (countries presented in alphabetical order, current emissions rounded to 1 Mt, share of global emissions indicated with two significant digits).

Country	Current emissions ($MtCO_2e$ 2010)	Share of global emissions (% world total 2010)
Azerbaijan	50	0.10
Bangladesh	184	0.37
Bolivia	144	0.29
Cuba	58	0.12
Ecuador	54	0.11
Guinea	230	0.46
Iraq	191	0.38
Islamic Republic of Iran	528	1.1
Kenya	56	0.11
Kuwait	101	0.20
Lao, People's Democratic Republic	100	0.20
Libya	79	0.16
Malaysia	330	0.66
Mali	50	0.10
Myanmar	362	0.72

***Table 2.3**. Continued*

Country	Current emissions ($MtCO_2e$ 2010)	Share of global emissions (% world total 2010)
Nigeria	215	0.43
North Korea	96	0.19
Oman	82	0.16
Pakistan	340	0.68
Philippines	159	0.32
Qatar	112	0.22
Saudi Arabia	495	0.99
Serbia and Montenegro	82	0.16
Sudan	195	0.39
Syrian Arab Republic	68	0.14
Thailand	413	0.82
Trinidad and Tobago	57	0.11
Turkey	420	0.84
Turkmenistan	87	0.17
Uganda	58	0.11
United Arab Emirates	207	0.41
United Republic of Tanzania	70	0.14
Uzbekistan	174	0.35
Venezuela	310	0.62
Vietnam	306	0.61
Zambia	77	0.15
Source: JRC/PBL (2012) (EDGAR 4.2 FT2010): http://edgar.jrc.ec.europa.eu/overview.php		

2.5 Comparison of current and expected emissions and emission intensities in 2020 for G20 countries with a pledge

Figure 2.6, Figure 2.7 and Figure 2.8 provide a comparison of the emissions of countries included in the G20 with a pledge, treating the European Union as a group. The figures put the pledges in perspective with historical trends and on a unit of GDP and per capita basis.

In terms of absolute emissions, most developed countries propose to reduce emissions by 2020 below the current level (2010), with the exception of Russia (see Figure 2.7). Developing countries generally propose to slow the speed of growth of emissions. The BaU provided by the countries themselves is often at the high end of the BaUs used by the modelling groups. Developing countries usually have higher emissions per unit of GDP than developed countries, in particular if the share of forestry emissions is high, as in Brazil and Indonesia. If pledges were complied with, emissions per unit of GDP would be reduced significantly for all countries. Countries like India and China have used this metric for the formulation of their pledge. The striking decrease in greenhouse gas emissions per unit of GDP for China from 1990 to 2010 reflects the considerable degree to which China has managed to decouple greenhouse gas emissions from economic growth during this period.

Countries with very high per capita emissions (e.g. Australia, Canada and USA) reduce emissions per capita significantly under their pledge, but they still stay high compared to other countries (Figure 2.8).

2.6 Summary

The sections above highlight that greenhouse gas emissions continue to increase. Estimated BaU emissions as well as emissions under each of the four pledge cases for 2020 are now estimated to be 1-2 $GtCO_2e$ higher as compared to last year's Bridging the Emissions Gap Report. These increases are due to various factors, including that the studies incorporated this year have updated BaU estimates that take into account the recent increase in economic growth rates by emerging economies and have adopted a later start year. The update of the potential implications of the use of offsets also affects the calculations, particularly between the conditional-lenient and conditional-strict cases. It is noteworthy that the assumptions of strict versus lenient rules have larger implications for the estimated emissions in 2020 than the implementation of conditional versus unconditional pledges. Going from unconditional to conditional pledge assumptions results in a reduction in emissions of 2 $GtCO_2e$, whereas going from lenient to strict rules reduces emissions by 3 $GtCO_2e$[18].

18 These are the differences of two rounded values. They actually may be somewhat higher or lower if the original values rather than rounded values are used to compute the difference.

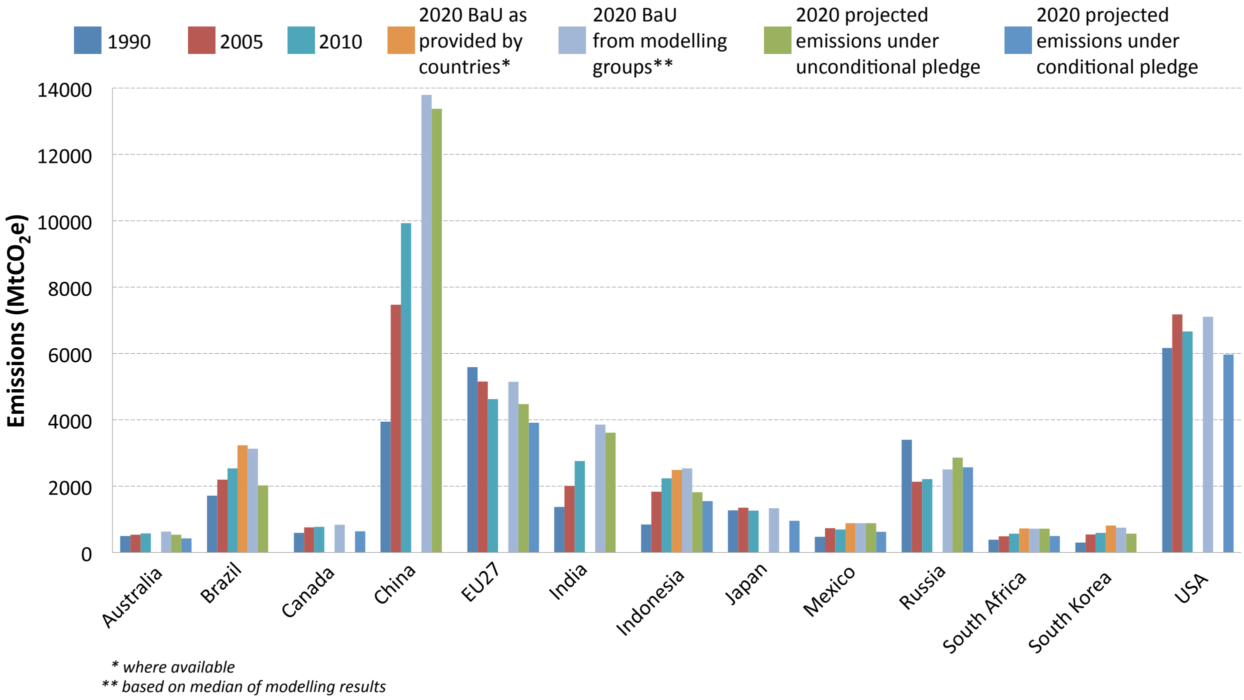


Figure 2.6. Year 1990, 2005, 2010 and 2020 greenhouse gas emissions for G20 countries that have made pledges. Note that European Union countries are taken as a group. *Source: JRC/PBL (2012); Government of Brazil (2010); Indonesia Ministry of Environment (2010); Mexico The Ministry of Environment and Natural Resources (2009); South Africa Department of Environmental Affairs (2011); South Korea Ministry of Land and Environment Protection (2000)*.

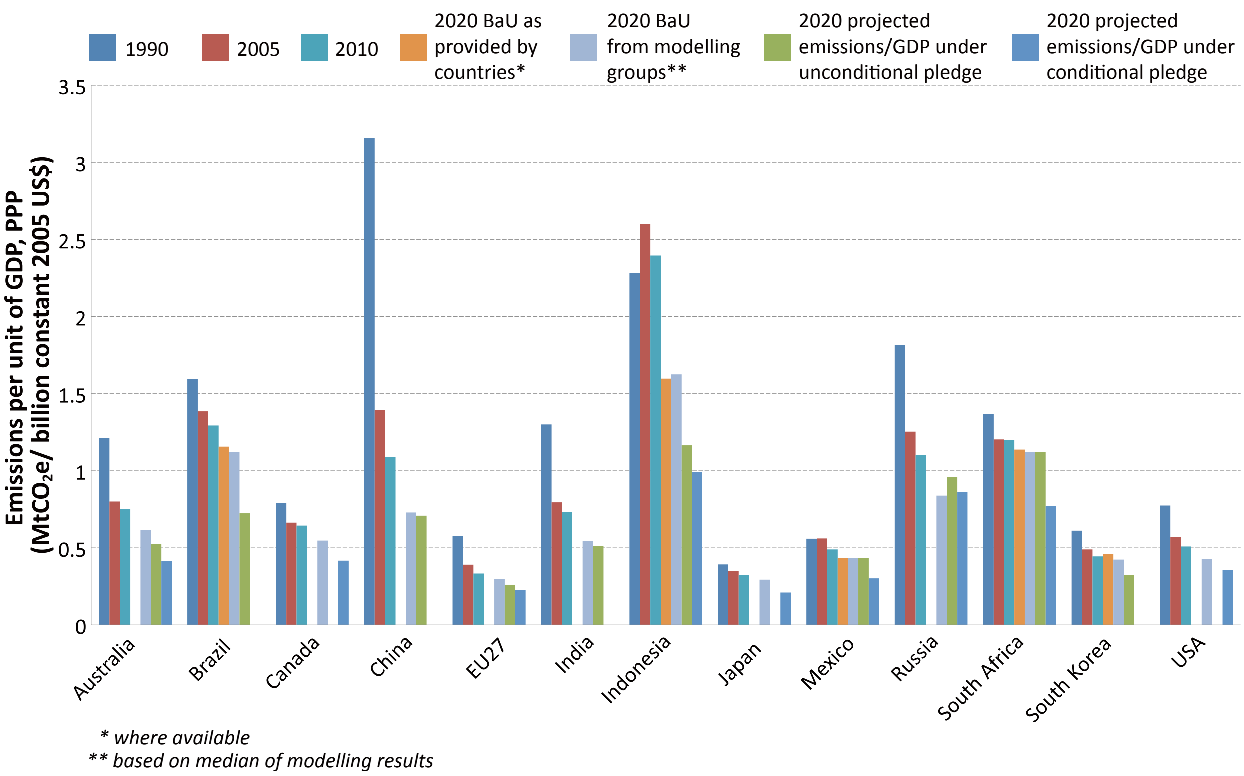


Figure 2.7. Year 1990, 2005, 2010 and 2020 greenhouse gas emissions per unit of GDP for G20 countries that have made pledges. Note that European Union countries are taken as a group. For emissions, see Figure 2.6. *Sources: GDP, Purchasing Power Parity (PPP) data; World Bank (2012).*

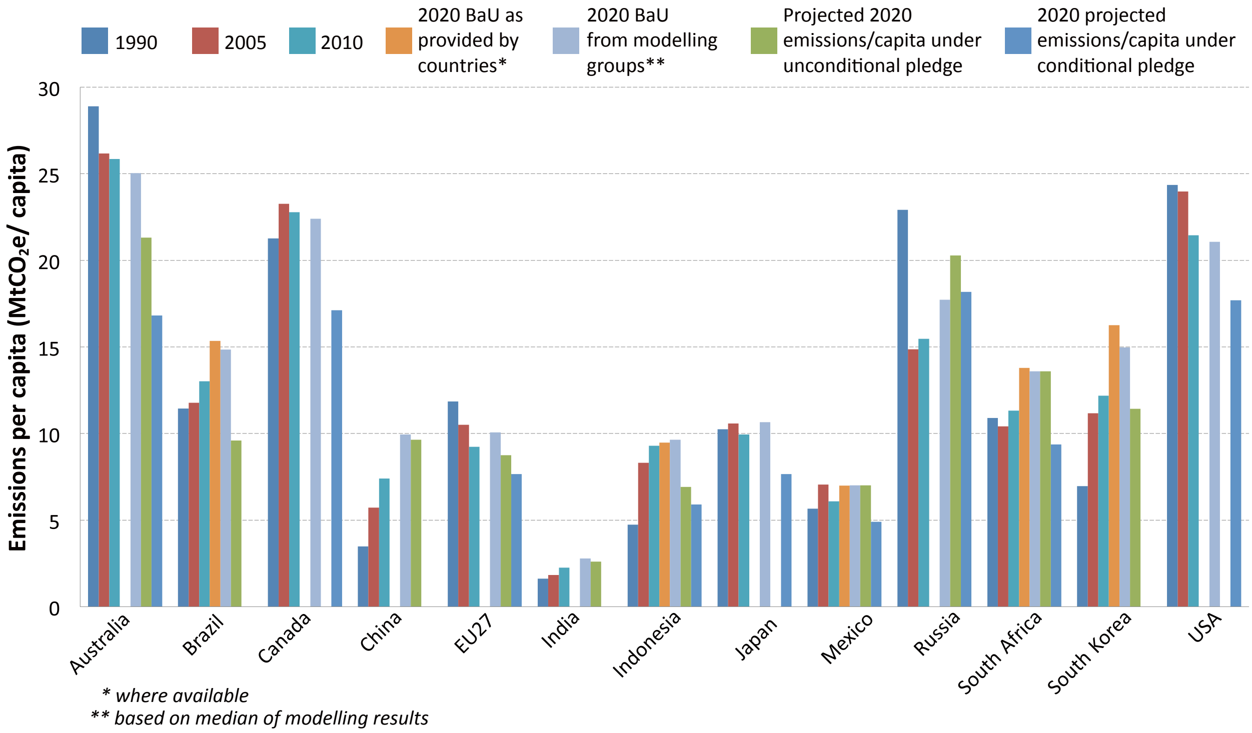


Figure 2.8. Year 1990, 2005, 2010 and 2020 greenhouse gas emissions per capita for G20 countries that have made pledges. Note that European Union countries are taken as a group. For emissions, see figure 2.6. *Source: UN medium population numbers; UN (2011).*

Chapter 3:

The Emissions Gap – An Update

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3.1 Introduction

This chapter updates the estimate of the emissions gap presented in the 2011 Bridging the Emissions Gap Report (UNEP, 2011) and presents new information about this gap. The "emissions gap" is the difference in 2020 between the level of global emissions consistent with climate targets and projected emissions. The projected emissions are calculated in Chapter 2 of this report. The climate targets considered in this report are the *2°C and 1.5 °C targets or limits* recognised in December 2010 at the annual Conference of Parties of the United Nations Framework Convention on Climate Change (UNFCCC) in Cancún, Mexico.

The Conference *"recognizes that deep cuts in global greenhouse gas emissions are required ...so as to hold the increase in global average temperature below 2°C above pre-industrial levels..., [and also] recognizes the need to consider... strengthening the long-term global goal on the basis of the best available scientific knowledge, including in relation to a global average temperature rise of 1.5°C"* (UNFCCC, 2010).

The chapter first briefly describes the scenarios that are analysed, and then identifies the emission levels in 2020 and other timescales that are consistent with a 2°C or 1.5°C temperature limit. The emission levels of these scenarios in 2020 are then compared to projected 2020 emission levels in order to assess the "gap". The implications of the gap and of other types of scenarios are then discussed.

3.2 Which scenarios are analysed?

The scientific literature documents many different emission scenarios that have temperature paths staying below an increase of 2°C or 1.5°C compared to pre-industrial conditions. In general, we know from the literature that there are many feasible pathways and options for staying below specific global temperature targets. One reason for this diversity is that most of these scenarios are computed by integrated assessment models (Box 3.1) which have different representations of socio-economic driving forces of emissions and different ways of portraying the chemistry and physics of the atmosphere. Therefore they each generate quite different emission scenarios that meet the same climate target.

Despite their diversity, the scenarios used in this chapter to compute the emissions gap have two things in common. First, they comply with either the 2°C or 1.5°C targets. Second, they are least cost scenarios (Box 3.2) and depict trends in global emissions up to 2100 under the assumption that climate targets will be met by the cheapest combination of policies and measures considered in a particular model. They further assume that actions begin "immediately", that is, in the specified base year of model calculations. Another type, called later action scenarios in this report, also limit greenhouse gas emissions to levels consistent with 2°C, but assume less short-term mitigation and thus higher emissions in the near term. Only at a point later than the base year do these scenarios introduce a least cost mitigation pathway to meet the global climate target[19].

Each of the scenarios has a particular trajectory of emissions through time. The reason a particular trajectory stays within a temperature target in the long term is because they stay within a certain limit of cumulative emissions over time. The amount of cumulative emissions has been found to be a good proxy for global temperature; the higher the cumulative emissions, the higher the level at which temperature stabilizes in the atmosphere (e.g., Allen et

19 These later action scenarios do not necessarily assume a complete absence of action in the near term; rather, they assume that near term action combined with more stringent action later (more stringent than in least cost scenarios) will successfully meet the 2°C target (for example, post-2020). The few currently available examples of these scenarios are evaluated later in the chapter.

Box 3.1 Integrated Assessment Models for Climate Change Assessments

The IPCC defines Integrated Assessment Models (IAMs) as “models that combine results and concepts from the physical, biological, economic and social sciences. They are used to model the interactions between these components in a consistent framework to evaluate the status and the consequences of environmental change and the policy responses to it” (IPCC, 2007a).

IAMs incorporate two main sets of factors determining the extent of climate change: the development of key socio-economic driving forces, and the physics and chemistry of the climate system. These two sets of factors at a minimum are needed to explore how society can move from a business-as-usual emissions path to a path which would limit global temperature increase to a certain target (in the case of this report, to below 2°C or 1.5°C). Several key socio-economic driving forces determine the future trajectory of emissions of greenhouse gases and other substances (e.g. aerosols). These driving forces include assumptions about economic growth, demographic change, technological development, consumer preferences and the introduction of climate policy. The physics and chemistry of the climate system determine how changes in emissions lead to changes in global average temperature.

al., 2009; Matthews et al., 2009; Meinshausen et al., 2009; Solomon et al., 2009; Zickfeld et al., 2009; Solomon et al., 2010; Bowerman et al., 2011; Smith et al., 2012).

Since two different trajectories can have the same cumulative emissions, this means that two or more trajectories can also meet a particular temperature target. That is why in this report we have identified 64 different scenarios that stay within the 2°C target with at least a 50% likelihood of success. But it also means that if emissions are somewhat higher at the beginning of the trajectory, they have to be lower at the end, and vice versa. This is called “intertemporal dependence” of emission trajectories. As an example, an emission trajectory that follows the top boundary of the “below 2°C” range (green range) in Figure 3.1, will result in a temperature increase which actually exceeds 2°C. To stay below 2°C, an emissions trajectory that starts at the top of the range must migrate to a lower part of the range. Conversely, a trajectory starting near the bottom of the range can move towards the top and still stay within the 2°C target.

It is important to note that the scenarios evaluated in this report were not explicitly generated to produce trajectories that stay below 2°C or 1.5°C. Rather, they were based on different climate targets such as greenhouse gas concentration levels, cumulative emissions over time, or

Box 3.2 What are Least Cost Scenarios?

Least cost scenarios are those computed by IAMs that identify the least expensive combination of mitigation options to fulfil a specific climate target. A least cost scenario is based on the premise that, if an overarching climate objective is set, society wants to achieve this at the lowest possible costs over time. It also assumes that global actions start at the base year of model simulations (usually close to the current year) and are implemented following a “cost-optimal” (cost-efficient) sharing of the mitigation burden between current and future generations depending on the social discount rate. This rate is a measure to help to guide choices about the value of diverting funds to social projects.

When creating such a least cost scenario, the model user can usually choose whether, when, how much, where, in which region, and through which available technology emission reductions are achieved. The model usually spreads mitigation efforts over all options and emission sources so that no mitigation option is neglected. The choices made by the model depend on the options selected by the user, whether these options are available in the model, how much they cost, what their mitigation potential is, the geographic coverage and amount of spatial detail of the model, and other factors. With this approach each IAM will provide a unique solution (i.e. combination of mitigation actions) for achieving a climate target. Because each model has a different representation of socio-economic driving forces and the physics and chemistry of the climate system (see Box 3.1), this approach results in at least as many solutions as there are models.

Least cost scenarios cluster into two general groups – those that assume that all the mitigation options (specified in an IAM model) can be selected during a particular model run, and those that place restrictions on the technical potential of an option, assuming for example that nuclear power is phased out during this century or that only half the potential of bioenergy is available because using more could demand too much of the world’s agricultural areas. In this report, however, we do not distinguish between these two types when we present results.

Although IAMs address the costs of mitigating emissions, they (usually) do not cover the economic and social costs of the impacts of climate change. Therefore a typical but incorrect conclusion is that a scenario without mitigation actions is less costly than an equivalent scenario with them. In reality, the opposite may be true – a scenario without mitigation actions may have higher net costs because of the high losses and damage due to climate impacts (for example, lower crop production and more frequent coastal and river flooding) and because of the considerable costs necessary to adapt to climate change.

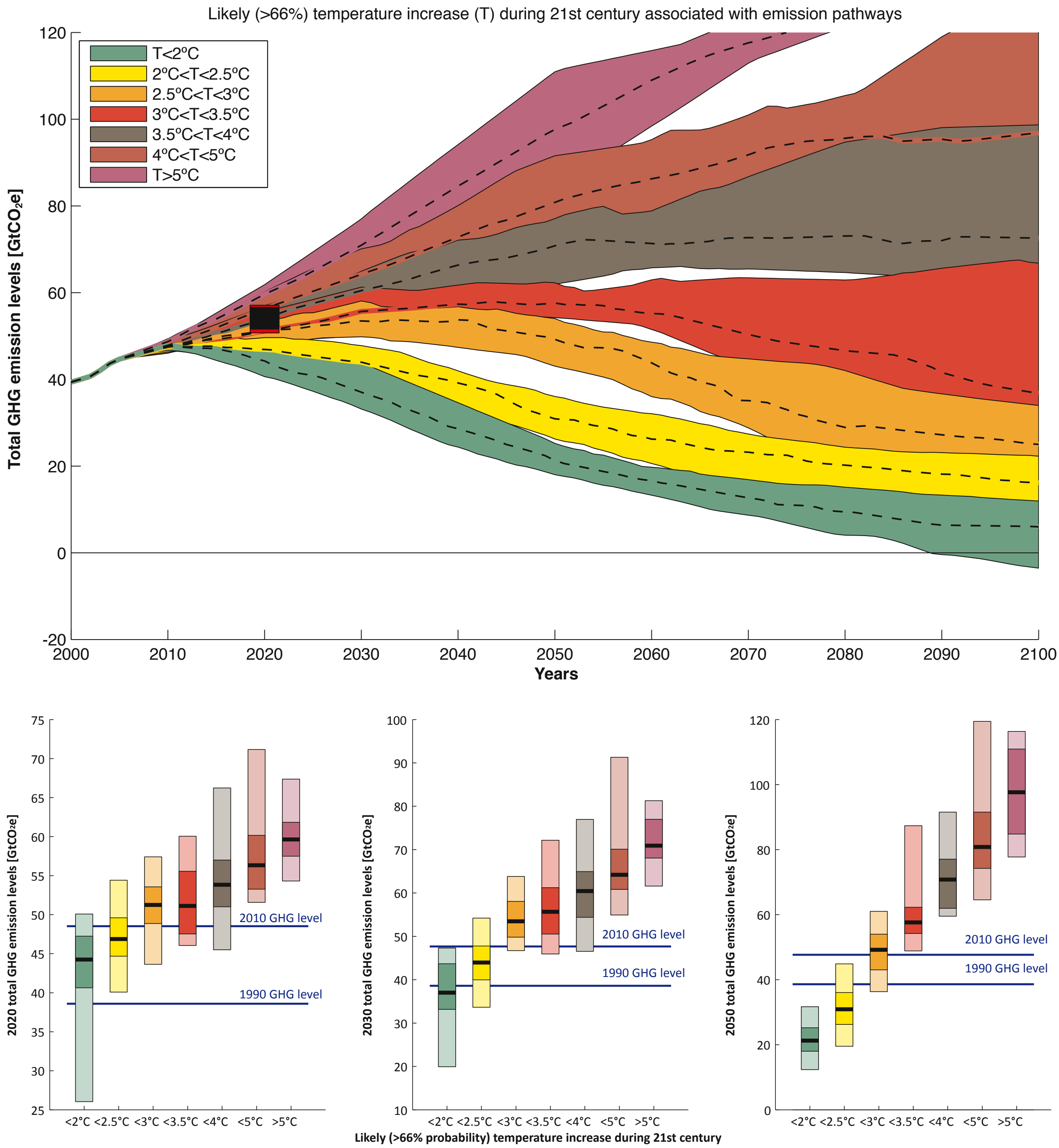


Figure 3.1: Ranges of pathways limiting global temperature increase with a "likely" (>66%) chance of staying below various temperature limits (top panel). Time slices of the ranges are shown in the bottom panel for 2020, 2030, and 2050 global total emissions, respectively. The small box around 2020 in the upper diagram indicates the emission levels consistent with the current pledges as assessed in Chapter 2.

radiative forcing. All these metrics are valid indicators for how to avoid "dangerous anthropogenic interference in the climate system", as stated in the Climate Convention (UNFCCC, 1992).

More details about the scenarios are given in Box 3.3.

3.3 Emission levels in 2020, 2030 and 2050 for the 2°C target

To analyse the least cost scenarios, we bring them into a common analytical framework and estimate the probability of each scenario exceeding 2°C and 1.5°C of warming. A probabilistic approach is important because of the great uncertainties of climate sensitivity (roughly speaking, the response of global temperature to additional greenhouse gas emissions) (Knutti and Hegerl, 2008) and transient climate response[20]. Temperature ranges are projected using the probabilistic carbon-cycle and climate model MAGICC[21](Meinshausen et al., 2011a) in a setup that closely simulates the global temperature response to greenhouse gas emissions of the most complex climate models (Rogelj et al., 2012) as assessed in the Fourth Assessment Report

20 According to the IPCC, transient climate response is a measure of the strength and rapidity of the surface temperature response to greenhouse gas forcing.

21 The setup of the climate model has been updated from the 2011 Bridging the Emissions Gap Report. Until now, the setup described in Meinshausen et al. (2009) was used. Here we use the setup presented in Rogelj et al. (2012), which is basically an extension of the work described in Meinshausen et al. (2009), to represent more closely the uncertainties in climate sensitivity in line with the assessment of the Intergovernmental Panel on Climate Change (IPCC, 2007b) and take into account the latest historical emission estimates from the Representative Concentration Pathway (RCP) exercise (Meinshausen et al., 2011b).

Box 3.3 Details about the scenarios analysed in this chapter

For this report, we re-analyse a large set (n = 290) of emission scenarios from the literature. In addition to the scenarios assessed in the Bridging the Gap report (UNEP, 2011), this year's report includes further scenarios from the Asian Modelling Exercise (Calvin et al., 2012) and the Global Energy Assessment (Riahi et al., 2012). Based on the assessment of current emissions in Chapter 2, scenarios with total greenhouse gas emissions in 2010 outside the 45.5 – 54.5 $GtCO_2e$/yr range were excluded (this affected 24 scenarios). Emissions are reported in units of annual gigatonnes of carbon dioxide equivalent ($GtCO_2e$/yr). Carbon dioxide equivalents of non-CO_2 gases are computed from the 100-year global warming potentials used by the UNFCCC (UNFCCC, 2002).

The emission estimates from different scenarios are harmonized to historical emission inventories by setting a common value for 2005, using the methodology from the Bridging the Gap report (UNEP, 2011). For the estimates of the emissions gap we include the emissions of greenhouse gases from the Kyoto Protocol. Although not explicitly included in the numerical estimates of the gap, model calculations also take into account the effect of a number of air pollutants that have an important impact on climate change, including sulphur dioxide (SO_2), black carbon (BC), organic carbon (OC) and tropospheric ozone with its precursors. Two of these, SO_2 and OC, have a cooling rather than warming effect on the atmosphere. We assume in our scenarios that the emissions and impact on global temperature of these substances will be gradually reduced over this century in line with a low-carbon future because of national air pollution reduction programmes (Meinshausen et al., 2011b; van Vuuren et al., 2011). We include their impact on global temperature using the same approach as in previous emission gap reports (UNEP, 2010; Rogelj et al., 2011; UNEP, 2011).

(AR4) of the Intergovernmental Panel on Climate Change (IPCC, 2007b). The methodology used for this analysis is described in more detail in UNEP (2010); Rogelj et al. (2011) and UNEP (2011).

The results here are not fundamentally different from those presented in the Bridging the Emissions Gap Report (UNEP, 2011). Emission scenarios in our set consistent with a "likely" chance of meeting the 2°C target do not exceed 44 $GtCO_2e$/yr (with a range of 41-47 $GtCO_2e$/yr) in 2020 (see Figure 3.1 and Table 3.1). In this and previous emission gap reports we define a "likely" chance as having a greater than 66% probability. For a less stringent "medium" chance (50 to 66 %), emission levels in 2020 can be somewhat higher at 46 $GtCO_2e$/yr (range 44-48 $GtCO_2e$/yr). Global emissions in these scenarios peak before 2020 or earlier.

Beyond 2020, emissions in 2030 do not exceed 37 $GtCO_2e$/yr (range 33-44) in the scenarios that have a "likely" chance of staying below the 2°C target. For a "medium" chance of staying below 2°C, 2030 emissions do not exceed 41 $GtCO_2e$/yr (range 39-46).

Emissions in 2050 consistent with a "likely" chance of being on a pathway to stay below 2°C do not exceed 21 $GtCO_2e$/yr (range 18-25). For a "medium" chance, the 2050 emissions level is 27 $GtCO_2e$/yr (range 24-29).

The larger ranges in 2030 illustrate that there is some flexibility in the exact timing of emission reductions, and the differences in assumptions between the different models play a role here. Nevertheless, there is agreement among the models that substantial emission reductions are required by 2050, and higher short-term emissions will have to be offset by steeper and deeper reductions later.

3.4 The emissions gap for the 2°C target

The "emissions gap" in 2020 is calculated by working out the difference between global emissions consistent with the 2°C target and expected emissions.

Figure 3.2 shows that the emissions gap compared to the Bridging the Gap Report has increased by about 1 to 2 $GtCO_2e$/yr for the pledge cases and by about 2 $GtCO_2e$/yr for the business-as-usual case (BaU). Reasons for this are given in Chapter 2.

The emissions gap in 2020 between BaU emissions and the emissions level consistent with a "likely" chance of staying within the 2°C target (44 $GtCO_2e$/yr) is 14 $GtCO_2e$/yr. The gaps between the four pledge cases and a "likely" chance of staying within the 2°C target are as follows:

- Case 1 – "Unconditional pledges, lenient rules" = 13 $GtCO_2e$/yr (range 9-16 $GtCO_2e$/yr)
- Case 2 – "Unconditional pledges, strict rules" = 10 $GtCO_2e$/yr (range 7-14 $GtCO_2e$/yr)
- Case 3 – "Conditional pledges, lenient rules" = 11 $GtCO_2e$/yr (range 7-15 $GtCO_2e$/yr)
- Case 4 – "Conditional pledges, strict rules" = 8 $GtCO_2e$/yr (range 4-11 $GtCO_2e$/yr)

Since the first UNEP Emissions Gap Report (UNEP, 2010), there has been a significant increase in the smallest estimate of the emissions gap for 2°C, from 5 to 8 $GtCO_2e$/yr for Case 4. The maximum gap extent, (Case 1) has increased from 7 to 13 $GtCO_2e$/yr. These increases stem from higher estimates of emission levels implied by the pledges, based on more elaborate analysis made possible by countries clarifying the meaning of their pledges. The median emission levels in line with a "likely" chance of staying below 2°C have not changed since the 2010 report (UNEP, 2010).

3.5 Results for a 1.5°C target

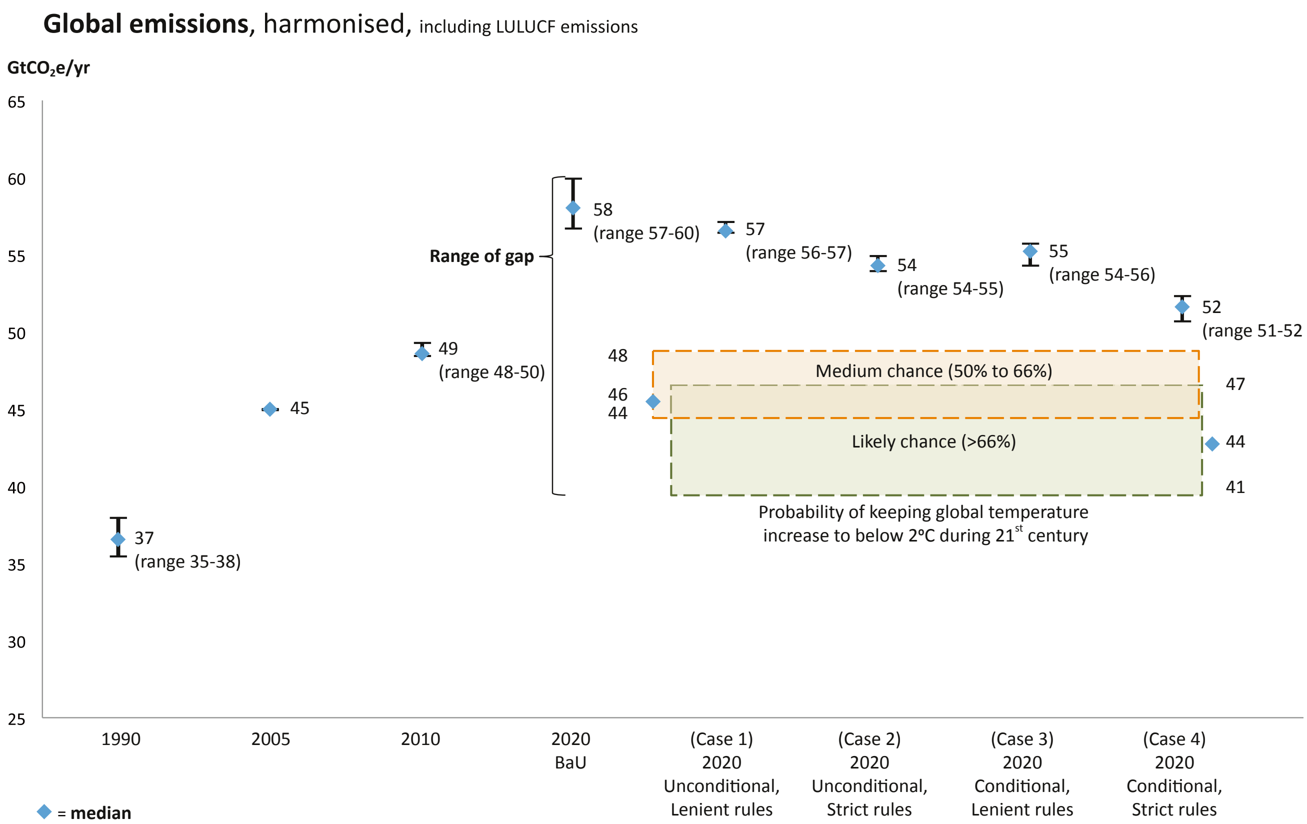
The previous section showed that pledges are far from able to close the emissions gap in 2020 or to lead to a pathway to stay within the 2°C target. However, as noted above, the Cancún Accord also makes provision for a possible 1.5°C target. From the set of 290 emission scenarios considered in this report, only five meet the 1.5°C target by 2100. These

Table 3.1: Overview of emissions in 2020, 2030 and 2050 of pathways with a “likely” (greater than 66 %) or a “medium” (50 to 66 %) chance of limiting global temperature increase to below 2°C during the 21st century, respectively.

	Number of pathways	Peaking decade*	Total GHG emissions in 2020		Total GHG emissions in 2030		Total GHG emissions in 2050	
	[-]	[year]	[$GtCO_2e$]		[$GtCO_2e$]		[$GtCO_2e$]	
			Median	Range**	Median	Range**	Median	Range**
Limit global temperature increase to below 2°C during the 21st century with:								
“Likely“ chance (>66%)	39	2010-2020	44	26-(41-47)-50	37	20-(33-44)-47	21	12-(18-25)-32
“Medium“ chance (50 to 66%)	25	2010-2020	46	40-(44-48)-52	41	36-(39-46)-53	27	20-(24-29)-36

* Because most IAM pathways provide emissions data only for 5-year or 10-year increments, the encompassing period in which the peak in global emissions occurs is given. The peak year period given here reflects the 20th – 80th percentile range. With current emissions around 50 $GtCO_2e$/yr, pathways with 2020 emissions below that value would in general imply that global emissions have peaked.

** Range is presented as the minimum value – (20th – 80th percentile) – maximum value



		BaU	Case 1	Case 2	Case 3	Case 4
What is the expected “gap” for a “likely” chance of staying below 2°C? (In parenthesis - figure of the 2011 assessment)	Median gap ($GtCO_2e$)	14 (12)	13 (11)	10 (9)	11 (9)	8 (6)
	Gap Range ($GtCO_2e$)	10-19 (9-18)	9-16 (7-16)	7-14 (6-14)	7-15 (6-14)	4-11 (3-11)
What is the expected “gap” for a “medium” chance of staying below 2°C? (In parenthesis - figure of the 2011 assessment)	Median gap ($GtCO_2e$)	12 (10)	11 (9)	8 (7)	9 (7)	6 (4)
	Gap range ($GtCO_2e$)	9-16 (6-14)	8-13 (4-12)	6-11 (3-10)	6-12 (3-10)	3-8 (0-7)

Figure 3.2 Summary of the gaps that result from four different interpretations of how the pledges are followed, and for a “likely” (greater than 66%) and a “medium” (50-66%) chance of staying below 2°C.

are from Kitous et al. (2010); Magne et al. (2010); and from three other modelling groups in the Asian Modelling Exercise (Calvin et al., 2012). Although there are too few results to allow robust conclusions, the few available scenarios show that for a "medium" or lower chance of staying below the 1.5°C target, emissions in 2020 should not exceed around 43 $GtCO_2e$/yr. This is consistent with the 2010 Emissions Gap Report (UNEP, 2010) which concluded from "stylized"[22] emission trajectories that, to stay within the 1.5°C target, emissions in 2020 should not exceed 44 $GtCO_2e$/yr (range of 39 to 44). Furthermore, emissions in 2050 are 15 $GtCO_2e$/yr or lower in our scenarios with a "medium" chance of complying with the 1.5°C target. Scenarios consistent with the 1.5°C target require very stringent emission reduction rates of 3 to 5% per year (Schaeffer and Hare, 2009; Ranger et al., 2010; UNEP, 2010) after emissions peak, and assume some temporary overshooting of the target temperature. Some evidence from the literature suggests that staying within the 1.5°C target will require reductions of not only long-lived greenhouse gases like CO_2, but also shorter-lived gases such as methane (Shindell et al., 2012; Smith et al., 2012). It is anticipated that forthcoming studies will allow more robust conclusions.

3.6 Other findings from the least cost scenarios

The set of scenarios used to compute the emissions gap also provides valuable information about the type of mitigation that would close the gap in 2020 and would contribute to staying within the 2°C target throughout the rest of the century.

3.6.1 The role of a package of energy measures

The Global Energy Assessment (GEA) created a large set of energy transition scenarios[23] (Riahi et al., 2012) that are consistent with the 2°C target. The GEA found that limiting energy demand, electrifying the transport sector, and significantly expanding carbon capture and storage (CCS) and renewable energy production were the most critical conditions for staying within the 2°C target. While the GEA shows that there are many feasible ways to make an energy system transition consistent with 2°C, it also shows that if energy demand is not drastically reduced through energy saving and efficiency measures, significantly fewer options remain available.

3.6.2 The importance of renewable energy

The Special Report on Renewable Energy Sources and Climate Change Mitigation from the IPCC (Fischedick et al., 2011) provides the context for understanding the role of renewable energy (RE) in climate mitigation. It reviews 164 medium- to long-term scenarios from 16 different IAMs, highlighting the importance of interactions and competition with other mitigation technologies, as well as the evolution of energy demand more generally. The study showed that a great effort to increase energy efficiency would lessen the need for other technological options including nuclear, CCS, and renewable energy. This is discussed further in Section 3.6.4.

3.6.3 Negative emissions and how they can be achieved

"Net negative emissions" means that on a global basis more greenhouse gases are being intentionally removed from the atmosphere (e.g. by planting forests or through CCS) than are being emitted globally.

About 40% of the scenarios analysed earlier in this chapter with a "likely" chance of meeting the 2°C target will have net negative global greenhouse gas emissions before 2100. About 30% with a "medium" chance have negative emissions. Moreover, about 50% of the scenarios analysed earlier with a "likely" chance of complying with the 2°C target have negative energy- and industry-related CO_2 emissions by 2100. For scenarios with a "medium" chance, the figure is 60%, as higher short-term emissions in these scenarios have to be offset by steeper and deeper cuts afterwards.

To achieve "net negative emissions" many studies assume a large deployment of the BioCCS technology - bioenergy combined with CCS. As explained in an earlier emissions gap report (UNEP, 2010), this involves using large amounts of biomass to generate energy (taking up CO_2 from the atmosphere during its growth) and then capturing and storing underground or elsewhere the CO_2 released by combustion. In this way BioCCS in effect removes CO_2 from the atmosphere (Azar et al., 2010).

A number of scientific studies and assessments have demonstrated that the availability of BioCCS is a crucial determinant for the costs and achievability of low greenhouse gas concentration stabilization targets (Azar et al., 2010; Edenhofer et al., 2010; Tavoni and Tol, 2010; van Vuuren et al., 2010). For example, most scenarios surveyed in the IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation and consistent with the 2°C target expect only limited BioCCS deployment by 2020 (0.1-0.4 $GtCO_2$/yr), but see an important expansion of this option by 2050/2100 (2.2-12.4 $GtCO_2$/yr / 4.3-25.3 $GtCO_2$/yr) (based on Fischedick et al., 2011).

Whether BioCCS is considered in a scenario has important implications for the timing of emission reductions. For instance, scenarios without BioCCS show significantly more stringent emission reductions over the short term, to compensate for the lower mitigation potential later (Figure 3.3). As most new studies include BioCCS in their standard technology portfolio, the allowable 2020 emissions of new scenarios are typically higher than in older scenarios. One study (Van Vuuren and Riahi, 2011) showed that scenarios with BioCCS have CO_2 emissions almost 10 $GtCO_2$/yr higher in 2020 than scenarios without it. However, some least cost scenarios manage to stay below 2°C without a contribution from BioCCS (van Vuuren and Riahi, 2011; Riahi et al., 2012). No scenarios with 2020 emissions more than 20% higher than in 2000 (lower than any of the cases assessed in the previous chapter[24], Figure 3.3) have been developed that

22 Stylized emission scenarios are scenarios that are designed to better understand the relationships between emissions and temperatures but do not explicitly incorporate assumptions about technological, economic or socio-political feasibility of emission reductions.

23 Available at: http://www.iiasa.ac.at/web-apps/ene/geadb/

24 Note that the increase in total greenhouse gas emissions is taken as a proxy for the increase in CO_2 emissions from fossil fuel and industry.

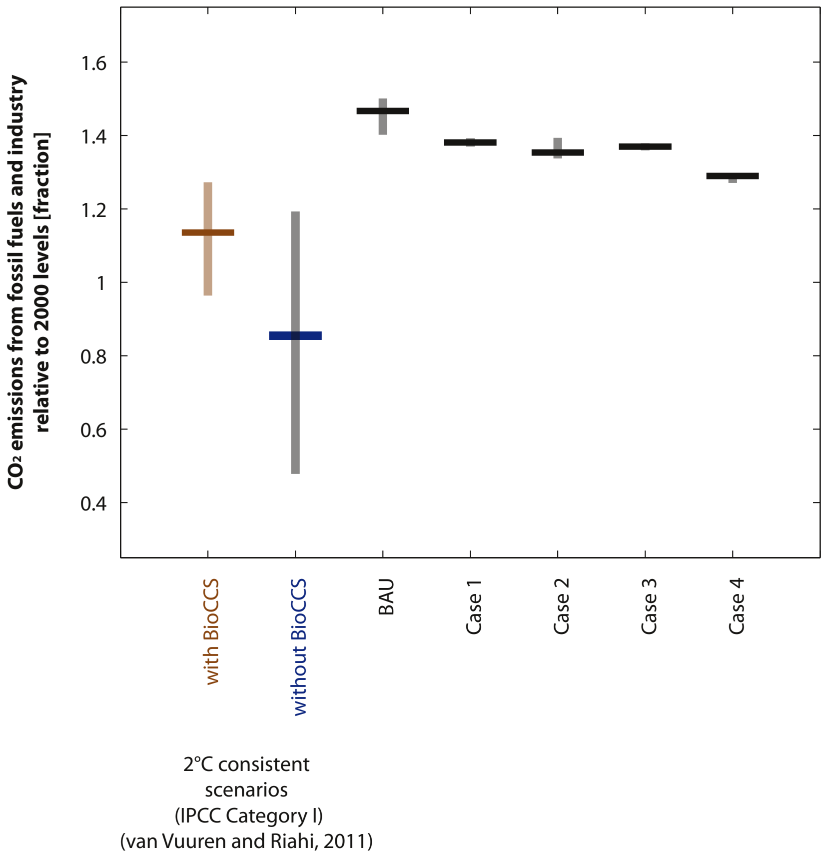


Figure 3.3. Comparison of 2020 emissions of pathways roughly consistent with staying below 2°C with and without BioCCS, and the pledge cases.

achieve this (van Vuuren and Riahi, 2011; van Vliet et al., 2012). This implies that scenarios with higher emissions in 2020 increasingly rely on negative emission technologies, like BioCCS, to compensate for the lack of short-term reductions. In fact, any restriction on the potential of any other mitigation options would have a qualitatively similar effect on short-term emissions. In other words, the estimates for emissions in 2020 consistent with the 2°C target depend very strongly on the feasibility of long-term mitigation measures like BioCCS.

The feasibility of large-scale BioCCS deployment for climate change mitigation crucially hinges on two factors. The first is the technical and social feasibility of large-scale CCS; for example, the development of a CCS infrastructure and the agreement of communities to accept CCS (Johnsson et al., 2009; Brunsting et al., 2011). The second is the technical and social feasibility of sustainable large-scale bioenergy production; for example, the development of second generation bioenergy conversion technologies, such as for producing fuels from woody biomass, or policy frameworks that control direct and indirect land-use emissions caused by bioenergy production (Chum et al., 2011). Even if these conditions are met, large scale bioenergy deployment may have severe implications, for instance on food prices. Many IAMs do not yet fully represent relevant processes that may limit the availability of bioenergy (Creutzig et al., 2012).

The feasibility and consequences of large-scale bioenergy systems are also related to the availability of sufficient land and water, their impact on biodiversity, and the productivity of biomass. If negative CO_2 emissions at a significant scale are not possible, then the options for meeting the global temperature targets will be significantly limited.

Negative emissions can also be achieved through concerted afforestation efforts or direct air capture of CO_2 in combination with CCS. While direct air capture is typically not included in IAMs, most models include afforestation and/or BioCCS.

3.6.4 The advantages of lower energy demand

As noted above, the GEA assessment (Riahi et al., 2012) and the IPCC assessment (Fischedick et al., 2011) indicate the paramount importance of demand-side efficiency and conservation measures for future reductions of greenhouse gas emissions. The basic idea is that low energy demand provides more flexibility for the supply side of the energy system, allowing comparatively higher emissions around 2020 (a low energy demand future implies reductions of demand in developed countries and a slower growth of demand in developing regions). A headline conclusion of the GEA scenario assessment is that a low level of global energy demand would make it possible to reach the 2°C and other sustainability targets without relying on nuclear energy and/or CCS. By comparison, if energy demand is higher, both technologies will be needed to meet the 2°C target (see Figure 17.13 in Riahi et al., 2012). Another important finding is that significant efficiency improvements would make possible an energy transition with limited reliance on bioenergy and with no reliance on carbon sink management or BioCCS.

An additional message from these studies is that the speed of the energy supply side transition need not be so rapid if there is a major push for efficiency (although they assume that energy-related emissions will peak by 2020 or soon after). Up to 2030, for example, the primary energy supply mix under low-demand scenarios meeting the 2°C target is only modestly different from today's. However, if energy efficiency continues to improve at only current rates, then more radical changes in energy supply will be required over the next two decades, and there will be greater dependence on nuclear power, bioenergy, or other low-carbon technologies.

3.7 Results of later action scenarios

The preceding sections have outlined results from least cost scenarios that assume immediate, coordinated mitigation actions. In this section, we discuss results from the later action scenarios. As noted earlier, these scenarios assume less short-term mitigation (and therefore have higher emissions in the near term) and begin a least cost mitigation pathway towards a global climate target only at a point later than the base year. The short-term mitigation action in these scenarios would be compatible with 2°C only with much more stringent action later. Just a few studies on later action scenarios have been published, for example, Clarke et al. (2009); OECD (2012); van Vliet et al. (2012); Rogelj et al. (in press), but more are forthcoming[25], which is why this report only reviews briefly the first findings of such scenarios.

By exploring the extent to which such later action scenarios are feasible within the constraints specified in IAMs, these scenarios provide insights beyond "optimal solutions" and reveal trade-offs. At least five principal trade-offs of later action pathways have already been identified (Clarke et al., 2009; den Elzen et al., 2010; van Vuuren and Riahi, 2011; Jakob et al., 2012; OECD, 2012; van Vliet et al., 2012; Rogelj et al., in press):

(i) increased short-term flexibility (short-term emissions are higher),
(ii) higher technological dependency (due to the need for a higher rate of future emission reductions),
(iii) higher overall costs,
(iv) pressure on future policy requirements and societal choices, and
(v) increased climatic risks.

Each of these is discussed in more detail below.

3.7.1 Increased short-term flexibility

A key characteristic of later action scenarios is that they show by definition a higher degree of short-term flexibility for emissions reductions than pathways that assume immediate action. In other words, they have higher near term emissions. The setup of these scenarios mimics situations in which some countries and economic sectors do not immediately participate in mitigation actions, or in which short-term emissions are consistent with the current level of country pledges. They may also resemble a situation in which the short-term economic burden of mitigation action is reduced by assuming more action later.

3.7.2 Higher technological dependency

Later action scenarios aim to compensate for higher short-term emissions with faster and deeper reductions later. Such reductions generally rely on optimistic assumptions about long-term and uncertain mitigation options. In these scenarios, not only is the availability of specific technologies very important, but also the pace at which such technologies can be scaled up. For example, recent studies (OECD, 2012; van Vliet et al., 2012) have found that emission levels in 2020 resulting from an optimistic compliance with country pledges[26] (which according to the least cost analysis in this report would cause an emissions gap) would have a "likely" chance of staying within the 2°C target if BioCCS was later used on a very large scale. The problem with becoming very dependent on future technologies is that if they do not realise the potential assumed in the scenarios, society will have fewer options to achieve the necessary emission reductions. This is a key point because some studies focusing on possible technology barriers and risks (e.g., Riahi et al., 2012) show that under unfavourable conditions, it might even be impossible to achieve the 2°C target from much lower 2020 emissions.

3.7.3 Higher overall costs

Later action scenarios result in lower short-term costs but often in higher overall costs. These costs are not evenly distributed over time. For example, a pathway with no mitigation action by 2020 will see emissions rise during this decade while mitigation costs up to 2020 will be zero. However, after that, higher emission reduction rates will be required[27]. As a result, pathways with high 2020 emissions will have markedly higher mitigation costs post-2020 in order to limit warming to below 2°C. For example, tentative results from a limited set of scenarios (van Vliet et al., 2012) indicate mitigation costs after 2020 that are 10-15% higher[28] than in least cost scenarios when 2020 emissions are equivalent to that of Pledge Case 4 in Chapter 2 (which was shown earlier not to close the gap)[29]. Another study (Jakob et al., 2012), which used three energy-economy models to explore the consequences of no mitigation action until 2020, found similar cost penalties compared to the least cost scenarios. Finally, OECD also reports that a later action scenario would require substantial additional costs after 2020 compared to a reference least cost scenario (OECD, 2012).

25 Two major international modelling comparison projects, AMPERE (http://ampere-project.eu/web/index.php?option=com_content&view=article&id=2&Itemid=102) and LIMITS (http://www.feem-project.net/limits/), are presently under way to explore this question in more detail.

26 The optimistic interpretation of country pledges from Van Vliet and colleagues (2012) limits emissions in 2020 to 47 $GtCO_2e$/yr, compared to a 2010 level of 44 $GtCO_2e$/yr in their model.

27 To achieve a given reduction in the least cost way, a model will first implement the cheapest options. To further increase the reduction rate, only mitigation options that are equally or more expensive are available.

28 Van Vliet et al. (2012) provide cumulative discounted direct mitigation costs from 2010 to 2100. Therefore, no clear distinction can be made between mitigation costs before and after 2020. A 12-14% range of mitigation cost increases is provided for this metric. Because these costs are discounted and those before 2020 are negatively correlated with those that follow, the increase in post-2020 mitigation costs will be higher than the 12-14% range.

29 2010 emissions in van Vliet et al. (2012) are about 44 $GtCO_2e$/yr, more than 10% lower than the most recent global estimates (see Chapter 2). In fact, in absolute numbers, even the emissions in their unconditional pledges, lenient rules case (Case 1) are lower than the latest assessment of conditional pledges, stringent rules (Case 4 in Chapter 2).

3.7.4 Pressure on future policy requirements and societal choices

As noted, later action scenarios have higher near-term flexibility than least cost scenarios, partly because they do not assume immediate global participation in climate mitigation. On the other hand, all later action scenarios meeting the 2°C target and having emission levels in 2020 near to the most optimistic pledge cases in Chapter 2, assume full global participation in stringent climate mitigation from 2020 onwards (OECD, 2012; van Vliet et al., 2012). In this sense, the flexibility of a later action scenario may only be temporary.

In addition, later action scenarios reduce the choices societies are able to make about preferred mitigation technologies. While several least cost scenarios show that the 2°C target can be met without BioCCS (Azar et al., 2010; Riahi et al., 2012; van Vliet et al., 2012), no later action scenarios published up to now can meet the target without BioCCS.

3.7.5 Increased climatic risks

Later action scenarios pose greater risks of climate impacts for three reasons. First, in the near term more greenhouse gases accumulate in the atmosphere and there is the risk that they will not be compensated for later. Second, the risk of overshooting climate targets is higher (den Elzen et al., 2010; van Vliet et al., 2012; Rogelj et al., in press). Third, the rate of temperature increase is higher (OECD, 2012; van Vliet et al., 2012).

The first point raises the possibility that a key technology like BioCCS may not manage to realise its potential, or perhaps that future policymakers are unwilling to take on the higher costs of mitigation. If this happens, cumulative emissions of greenhouse gases might very well be higher than expected, and the Earth system would therefore be committed to greater warming and the likelihood of achieving the temperature targets would then decrease (e.g. Meinshausen et al., 2009).

The higher levels of near-term emissions in later action scenarios may also lead to a temporary overshoot of climate targets (Clarke et al., 2009; den Elzen et al., 2010; van Vliet et al., 2012; Rogelj et al., in press), or may make such an overshoot longer and more pronounced (particularly in the case of a 1.5°C target). Overshooting these targets in principle implies a greater risk of large-scale and possibly irreversible changes in the climate system: the temperature targets are in part designed to avoid such changes. Although inertia in the Earth system can provide some resilience to rapid changes (e.g. Ridley et al., 2010; Good et al., 2011), the longer the temperature remains at higher levels, the greater the probability of rapid and significant climatic changes and impacts.

Finally, the OECD Environmental Outlook to 2050 (OECD, 2012) reports that a later action scenario that starts from 2020 emission levels consistent with a stringent interpretation of the country pledges would cause a 10% higher annual temperature increase in the coming decades than in the least cost case. The rate of temperature increase would therefore also be influenced by later mitigation action.

3.8 Present UNFCCC policy options to bridge the gap

Chapter 2 showed that applying strict accounting rules for LULUCF, surplus AAUs, and double-counting of offsets (currently being discussed within the UNFCCC climate talks) can lead to significantly lower emissions in 2020. Strict rules have an even bigger effect on reducing the emissions gap when they are combined with higher ambition levels.

3.9 The implications of current emissions levels and the emissions gap

Summing up, the analysis of least cost scenarios shows that a gap exists between the pledges and robust paths towards limiting global warming to below 2°C. Emissions are still on the rise and the available cumulative emission budget consistent with 2°C is being used up fast. The median cumulative emission budget from 2000 to 2050 in the pathways which are consistent with 2°C with a likely (>66%) probability is around 1890 $GtCO_2e$. Between 2000 and 2010, 24% of this budget was used, and in the past three years at least 8% more was used, leaving only around two-thirds (about 1250 $GtCO_2e$) for the years up to 2050.

Importantly, the 2011 UNEP Bridging the Emissions Gap Report (UNEP, 2011) showed that mitigation options that go beyond current pledges are available at low to moderate costs. They could close the gap and bring 2020 emissions in line with limiting global temperature increase to below 2°C, thereby leaving the possibility open of returning to below 1.5°C by 2100.

Later action scenarios may avoid near-term mitigation costs, but at the expense of stronger future reliance on specific technologies, less flexibility for future generations in their choice of mitigation measures, higher overall costs, and higher climate risks. If mitigation is limited to current pledges, then the world could be on a pathway to one of these later action scenarios.

Finally, the findings of Chapters 2 and 3 (especially Figure 3.1) show that the range of 2020 emission levels implied by current pledges is most consistent with pathways limiting global temperature increase (with a “likely” (>66%) chance) to 3 to 5°C above pre-industrial levels during the 21st century.

Chapter 4

Bridging the Emissions Gap

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4.1 Introduction

The analyses in Chapters 2 and 3 of this report concluded that the emissions gap in 2020 will likely be between 8 and 13 $GtCO_2e$. The chapters also estimated the difference between BaU emissions in 2020 and the emissions level consistent with a "likely" chance of staying within the 2°C target to be 14 $GtCO_2e$. This chapter explores the potential for bridging this gap using a sector policy approach.

Firstly, the chapter provides a summary and update of the estimated emission reduction potential by sector from the Bridging the Emissions Gap Report (UNEP, 2011). Secondly, it examines a number of sector-specific policies that have already been adopted by national or local governments in several countries and regions around the world, and that have been successful in reducing greenhouse gas emissions.

Without pretence of being comprehensive in either the choice of sectors or policy instruments, the focus of the second part of the chapter is on best practices in three sectors: buildings, transport and forests. Together, the emission reduction potential of these three sectors makes up roughly 40% of the total emission reduction potential estimated in the Bridging the Emissions Gap Report (UNEP, 2011).

Besides the relative importance of these sectors in terms of their contribution to greenhouse gas emissions, they also offer examples of how ambitious policy instruments that lead to significant emission reductions can foster innovation and economic growth, bolster national energy security, improve public health and address other key developmental priorities.

A key objective of the review of best practice policies is to demonstrate how they can be scaled up (both in ambition and geographical reach) in different countries and regions with due consideration to national differences and circumstances. Therefore, the chapter focuses not only on efficiency and equity issues, but also on political and economic factors that are the basis for successful policy design, implementation and enforcement. Regulatory issues of governance and legal and institutional settings are also discussed. Other policy instruments which could help achieve emission reductions in the power, industry, agriculture and waste sectors will be analysed in subsequent UNEP Emissions Gap Reports.

4.2 Emission reduction potentials by sector in 2020 – summary and update

4.2.1 Greenhouse gas emission reduction potentials based on sector studies

One approach to estimating the total emission reduction potential is to review detailed studies of the reduction potential by sector up to a certain marginal cost level. Adding up the sector estimates gives an indication of the total potential. Adopting this approach, the Bridging the Emissions Gap Report (UNEP, 2011) estimated the total emission reduction potential in 2020, at a marginal cost of about 50 – 100 US$/$tCO_2e$ to be in the range of 17 ± 3 $GtCO_2e$. A summary of the findings is provided in Table 4.1. As can be seen in the table, the uncertainty in the estimated emissions reduction potential for each sector is high. Hence, the value of the estimated emission reduction potential ranges from 10 to 23 $GtCO_2e$. However, if it is assumed that not all uncertainties are at their high end at the same time, then a more reasonable estimate of the emissions reduction potential would be 17 ± 3 $GtCO_2e$[30].

The mid-range of 17 $GtCO_2e$ confirms that the total emission reduction potential is sufficient to close the emissions gap between projected emissions based on country pledges and the emissions level consistent with a "likely" chance of staying below the 2°C target. The value also exceeds the estimated difference between projected BaU emissions in 2020 and the emissions level consistent with a "likely" chance of staying below the 2°C target (that is 14 $GtCO_2e$), noting that the low range of emissions reduction potential just equals this difference.

reported in the Bridging the Emissions Gap Report (UNEP, 2011) and summarised in Table 4.1.

The Global Transportation Energy and Climate Roadmap (ICCT, in press) estimates the emission reduction potential for the transport sector, including aviation and marine, in 2020 to be around 2 $GtCO_2e$. For buildings, the scenario analysis of best practice policies for low energy and carbon buildings (Ürge-Vorsatz et al., 2012) confirms the significant emission reduction potential of the building sector. For 2020, the study estimates an emission reduction potential of approximately 2.1 $GtCO_2e$ globally. Both estimates are well within the uncertainty ranges of the emission reduction potential of the transport and building sectors reported here.

Table 4.1 Sectoral greenhouse gas emission reduction potentials in 2020 compared to BaU, at marginal costs below 50 to 100 US$/$tCO_2e$, either explicitly or implicitly

Sector	Emission reduction potential in 2020 ($GtCO_2e$)
Power sector	2.2 – 3.9
Industry	1.5 – 4.6
Transport*	1.7 – 2.5
Buildings	1.4 – 2.9
Forestry	1.3 – 4.2
Agriculture	1.1 – 4.3
Waste	around 0.8
Total (Full range)	10 – 23
Total	17 ± 3 (Assuming not all uncertainties at their high end simultaneously**)

Source: UNEP Bridging the Emissions Gap Report (UNEP, 2011)

* including shipping and aviation
** see footnote 30

4.2.2 An update on sectoral emission reduction potentials

Since the release of the Bridging the Emissions Gap Report (UNEP, 2011), a number of studies have been published that provide new scenarios of relevance to bottom-up, sectoral assessments of energy-related greenhouse gas emission reductions. The studies include the three scenarios of the Global Energy Assessment (Johansson et al., 2012); an update of the Energy Technology Perspectives of the International Energy Agency (IEA, 2012); an update of the Energy Revolution scenarios prepared for Greenpeace, Global Wind Energy Council (GWEC) and European Renewable Energy Council (EREC) (Teske, 2012); a scenario based analysis prepared by the Global Buildings Performance Network and the Central European University (Ürge-Vorsatz et al., 2012b); and the Global Transportation Energy and Climate Roadmap, updating the Roadmap model (ICCT, in press). All of these studies have a long-term focus, leading up to 2050, and provide snapshots of mitigation opportunities in different scenarios.

As a first conclusion, the findings of these studies are consistent with the range of emission reduction potentials

Focusing on "current developments" rather than scenarios, the latest Energy Technology Perspectives report (IEA, 2012) highlights good progress over the past year for renewable power generation; moderate progress for industrial energy efficiency, vehicle fuel economy and the transition to electric vehicles; and disappointing results for power plant efficiency, nuclear power, carbon capture and storage, buildings and transportation biofuels. These developments may have an impact on the potential that can be realized in 2020.

A very positive development in recent years is the significant reduction in the cost of photovoltaic (PV) power generation. At the start of 2012, prices of photovoltaic modules were down 50% compared to a year earlier, and 76% below the level in the summer of 2008 (McCrone et al., 2012). Levelized Energy Costs[31] of generating electricity from photovoltaic systems are now in the range of 100 – 260 US$/MWh (McCrone et al., 2012). These developments have led some authors to adjust their 2020 estimates for installed solar PV capacity upwards (Krewit et al., 2010; Breyer, 2011; Teske, 2012). An increase of the installed photovoltaic solar capacity by as much as 500 GW will lead to an increase in

30 It is unlikely that all or several sectors will be simultaneously at the high ends of their uncertainty range. Therefore, assuming that the uncertainties are independent between sectors (which may hold under many cases) we can apply an error propagation rule to calculate the range of the sum of the sectors (the square root of the sum of the squares of the range for each sector). This gives a reduced range of ±3 Gt CO_2e compared to the full range of ±7 Gt CO_2e.

31 Levelized Energy Cost (LEC) refers to the price at which electricity must be generated from a specific source to break even over the project lifetime. It takes into consideration all the costs associated with an energy generating system over its lifetime including initial investment, operations and maintenance, cost of fuel, and cost of capital.

avoided emissions of 0.4 $GtCO_2e$. Although this is a very substantial potential contribution by one single technology, it falls within the uncertainty range for the total emission reduction potential indicated in Table 4.1. Together with the generally positive trend in renewable power generation, it is becoming more likely that the higher end of the potential estimated in UNEP (2011) would be achieved for this category.

4.2.3 The emission reduction potential is still significant, but time is running out

In summary, the review of recently published studies generally confirms the emission reduction potentials for 2020, as estimated in the Bridging the Emissions Gap Report (UNEP, 2011) and shown in Table 4.1. However, the mixed progress reported from different sectors (as highlighted in the latest Energy Technology Perspectives report (IEA, 2012); see Section 4.2.2 above) gives rise to concerns about the estimated emission reduction potential in 2020. This is particularly so because an important caveat to estimates of emission reduction potential is that they can only be realized if strong, long-term and sector-specific policies are in place at the global and national levels (UNEP, 2011).

Even if the potential remains the same, there is basically one year less to achieve this reduction, implying steeper and more costly actions will be required to potentially bridge the emissions gap by 2020. At the same time, any new investments in buildings, transportation systems, factories, and other infrastructure would fix energy use patterns for decades. Therefore, lack of action now will lead to a "lock in" of high energy use and emissions for a long period of time. Without ambitious policies, these investments may also lead to other consequences, including harmful pollution and increased energy demand which could result in higher energy prices. However, the rapid implementation of sound policies can steer those investments towards low-carbon technologies and sustainable growth.

4.3 Best practice policies

This section illustrates how a number of sector-specific policies that have already been successfully implemented in several countries and regions around the world have the potential, if scaled up both in ambition and geographical reach, to contribute to bridging the emissions gap.

4.3.1 Best practice policies in the building sector: building codes

Introduction

Building codes are regulatory instruments that set standards for specific technologies or energy performance levels and can be applied to both new buildings or to retrofits of existing buildings. The building sector contributes around 8% of global greenhouse gas emissions and approximately one third of all energy-related greenhouse gas emissions. In addition to the reduction potential for 2020 listed in Table 4.1, the sector has been recognized as having the largest longer-term, cost-effective greenhouse gas mitigation potential of any industrial sector (IPCC, 2007; Ürge-Vorsatz et al., 2012b).

While there is extensive greenhouse gas mitigation potential in the building sector, buildings are long-lived. A combination of slow turnover and retrofit rates implies that the shorter term potential is significantly below the longer term potential. A recent scenario-based study (Ürge-Vorsatz et al., 2012b) estimates the global emission reduction potential to be approximately 2.1 $GtCO_2e$ by 2020, but up to 9 $GtCO_2e$ by 2050[32]. To illustrate, this implies that by 2050, the building sector could consume 30% less energy compared to 2005, despite a close to 130% projected increase in built floor area over the same period. Figure 4.1 illustrates these scenarios.

"Lock-in" and urgency of action

The long-lived nature of buildings also implies that there is a risk of "locking in" energy inefficiencies resulting in emissions that are substantially higher than necessary. For instance, if policy development and reform continues at current rates (illustrated by the "moderate" scenario in Figure 4.1), it is estimated that emission reductions will be 1.6 $GtCO_2e$ in 2020 and 4.5 $GtCO_2e$ in 2050, in contrast to the 2.1 $GtCO_2e$ in 2020 and 9 $GtCO_2e$ in 2050 estimated to be technically and economically feasible.

The strength and appropriateness of building sector policies in place over the next few years will therefore determine total building emissions for several decades to come – pointing to the advantages of quick action. If the building sector is to reduce emissions sufficiently to contribute to achieving the 2°C target, policy packages containing state of the art building codes may need to become mandatory over the next 10 years in all the major economies such as the USA, India, China and the European Union (Ürge-Vorsatz et al., 2012b).

Policies that work

Building codes are an example of visible success in the field of climate-related policy-making. Few other areas exist where policies have been put in place over the last decade to achieve significant emission reductions, while providing the same or even increased service levels. Leading European countries have used the last 20 to 30 years to develop and increase the stringency of building energy policies. However, China has taken only a decade to develop and implement its first generation codes and under the 12th five year plan is rapidly increasing the stringency of codes and mandating the application of energy efficiency standards to renovation projects. In the USA, two sets of codes are in place, but there is potential for further action (see Box 4.1).

Building codes that set minimum energy performance requirements have proven to be among the most effective policy tools for cost-effective energy savings and greenhouse gas reductions (UNEP, 2008). To be most effective, they should be implemented as a core element of integrated packages of regulatory standards, financial incentives, and voluntary programmes (Ürge-Vorsatz and Koeppel, 2007). In practice, building codes have proven more efficient than

32 These figures refer to all buildings, including residential, public and commercial, and cover heating, cooling and hot water energy use.

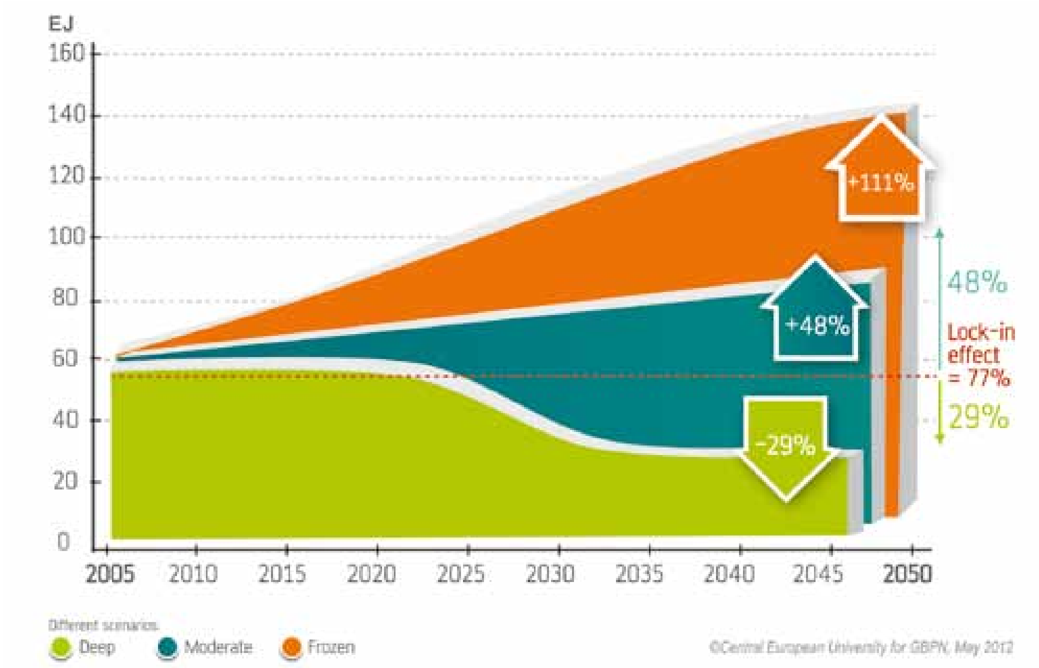


Figure 4.1 Three scenarios of total world thermal energy use in buildings. *Source: Ürge-Vorsatz, D., et al. (2012)*[33]

33 The scenarios are based on the following assumptions:
(a) 'frozen' scenario: A baseline scenario, where energy performance of new and retrofit buildings does not improve as compared to their 2005 levels,
(b) 'medium' scenario: Assuming that the current rate of policy development and reform continues,
(c) 'deep' scenario: State-of-the-art policies adopted as integrated packages.

Box 4.1 Building codes in the EU, USA and China

EU: Reducing the energy required for heating has been a major focus of building energy policies in the European Union, where the existing building stock is large and rates of replacement are relatively low, and where a majority of the population live in cool to moderate climate zones. The EU Energy Performance in Buildings Directive is the key policy framework for driving low energy consumption in new and existing buildings. Introduced in 2002, it creates an integrated basis for the implementation of performance-based, rather than prescriptive building codes and supporting policy strategies. It sets common targets for absolute reductions in energy consumption across the EU member states. In 2010 the Directive was recast with more stringent energy reduction targets, including the requirement for member states to implement "Near Zero Energy" building codes. However, it still faces challenges in implementation and compliance, since there are significant variations among member states (Levine et al, 2012).

USA: Buildings in the USA have the highest energy consumption relative to population compared to other places where codes have evolved over the last decades. The International Energy Conservation Code and the codes of the American Society of Heating, Refrigerating and Air-conditioning Engineers, as well as other variants of these codes, are applied to all major new building types in the USA with varied stringency by different states, creating a patchwork of effectiveness in the code environment. California, the Pacific Northwest, and some Northeast states lead in terms of rapid implementation of national model codes. However, there is a potential to move to more performance-based codes in order to facilitate absolute energy reduction targets, such as "Net Zero Energy" buildings (Levine et al, 2012).

China: As in most emerging countries, new buildings are the priority for emissions reduction in China. China adds about 1.7 billion square meters of new building floor area annually (Bin and Li, 2012) and buildings in China currently account for nearly 20% of total annual primary energy consumption and greenhouse gas emissions. Over the past twenty years China has made great efforts to reduce heat loss in and improve efficiency of space heating in the northern regions, in particular in residential buildings. Three design standards now cover four out of the five climate zones of the country (Levine et al., 2012). China has also recently introduced building energy performance codes for new public and commercial buildings in all climate zones.

market-based instruments[34] in the residential and commercial sectors, due to market imperfections such as owner-tenant and builder-occupant split incentives; inadequate information and associated high transaction costs; risk aversion towards higher first-costs; first-cost psychology barriers; and other factors.

In general, effective policies for reducing greenhouse gas emissions from the building sector set targets for absolute energy performance for new buildings and occasionally for

34 Market-based instruments harness market forces (e.g., prices, taxes, levies, subsidies and other economic variables) to encourage the adoption of good practices.

retrofits[35]. Absolute targets provide a more certain policy environment for market transformation that can help drive demand for more energy efficient buildings (Economist Intelligence Unit, 2012). Policy targets for mandatory energy efficient renovation of existing buildings are under way within the European Union and in different parts of China and the USA. Although state-of-the-art, these targets have yet to become widely implemented in building codes, which implies that even in the most progressive jurisdictions, there is significant potential for scaling up mandatory energy efficient renovation to further reduce emissions (Ürge-Vorsatz et al., 2012b).

With regard to cost-effectiveness, very few studies exist that rigorously evaluate cost-effectiveness on a comparable basis. Available estimates however, show attractive ranges. For example, one study estimates that emission reductions from buildings in the EU region could have an average cost of less than 36.5 US$/t$CO_2$e with a cost range spanning –109 to 49 US$/t$CO_2$e (Kiss et. al., in preparation). Generally, the overall cost-efficiency that can be achieved will be dependent on the design of the building code and how the code is implemented.

Drivers and co-benefits

Building regulations are often not motivated by environmental or energy reasons. Instead, they are advanced to promote safety, save costs, or for other socioeconomic reasons. In addition, well-designed and implemented building codes are associated with major co-benefits (see, Tirado et al., 2011). First of all, the general co-benefits related to improved energy efficiency all prevail, including improved energy security and social welfare, improved outdoor air quality and related health and productivity, and competitiveness gains.

Very high performance buildings also result in significant gains in values of the building infrastructure and ability to rent out properties.

Large retrofit programmes have been assessed to have important net employment benefits, even when employment losses in the energy supply sector are considered. A study of a broadly implemented ambitious retrofit programme in Hungary reported a significant net employment gain (Ürge-Vorsatz et al., 2010). The employment created by ambitious retrofit programmes is mostly localized and not exportable because it requires on-site labour, thus contributing to regional and local development goals.

Lessons and scope for scaling up

While there have been major successes in policies that reduce energy use of buildings around the world, often these measures merely constitute the tip of the iceberg. Scaling up efforts in terms of ambition in energy performance levels, building types covered (new and retrofit), and geographic regions, presents an exceptional opportunity for emission reductions from the building sector that could dwarf any reductions already accomplished or planned up to now.

Compared to code frameworks in the USA, China and India, the EU's Energy Performance in Buildings Directive has had greater success in achieving deep reductions in thermal energy required by buildings (Urge-Vorsatz et al., 2012b). It is therefore tempting to suggest that all regions should follow the EU's lead. However, effective development and implementation of building codes is very site specific and depends on cultural practices. For example, market-based mechanisms are important for steering building improvements where a more liberal ideology is prevailing, as exemplified by building regulations in the USA. However, in Europe there is greater acceptance of government-led programmes supported by voluntary measures (Levine et al., 2012). In China there is a greater acceptance of central government implementation and enforcement of building codes (Bin and Li, 2012), while in India there appears to be a tension between state level implementation and a propensity for self-organization at the local level (Kochar, 2010).

Another lesson for scaling up and for the time frame in which emission reductions can be achieved relates to codes for new buildings. In many developed countries, new building codes aimed at very ambitious performance levels (such as net zero energy), will have limited impact on emission reductions in the next few decades, since new construction is limited[36]. In developed countries, therefore, building codes related to retrofits can make the largest difference in heating and cooling related emissions during the next decades. By contrast, in fast growing and urbanizing developing countries, regulating new construction brings the largest short term emission reduction gains. Building codes for new urban buildings can attain large emission reductions, since 85% of the growth in building energy use up to 2050 will occur in urban areas, 70% of which will be in developing countries (Ürge-Vorsatz et al., 2012a).

This points to an important role of cities as engines for introducing ambitious building codes. Codes introduced at the city level can capture the lion's share of building-related heating and cooling mitigation potential. Cities are also very appropriate units for passing building code regulations because regulations work best when tailored to local climatic and cultural conditions. Besides, cities can often be more proactive and flexible in policy experiments than national governments. This is demonstrated by the proliferation of building-related performance mandates that cities have been adopting worldwide during the past decade primarily for climate reasons.

Enforcement is crucial for the effectiveness of building codes. Unfortunately the track record of building codes so far shows weak enforcement. It will be crucial to improve enforcement in order for building codes to become a key global mitigation strategy.

In conclusion, design and implementation of codes should be guided by cultural and governance characteristics, in addition to population density, variation of climatic zones and the age and typologies of buildings. Often, building

35 Existing buildings are more challenging to address through building codes because codes in this case would only be applied when the building is renovated, and that is not very often. Therefore, most policies have focused on new construction where it is enough to have more stringent performance levels prescribed to components or for the building as a whole.

36 The percentage of new construction also varies among developed countries. For instance, in Europe building lifetimes and retrofit cycles are long; whereas the USA experiences larger new construction rates due to population growth, shorter building lifetimes and retrofit cycles.

Credit: Franck Boston/Shutterstock.com

codes will be associated with co-benefits and in many cases it may be these benefits that drive building code policies, as they may be high priorities of local and national decision-makers. It is clear that there is significant untapped potential to reduce emissions through building codes. This is the case globally, regionally, nationally and locally. The ambition of policies within the next few years will not only determine the emissions reduction potential that can be realised in the building sector in 2020, but will also have major implications in the decades to follow.

4.3.2 Best practice policies in the building sector: appliance standards and labels

Introduction

Energy performance standards and labels for appliances, equipment, and lighting are instruments that offer a large opportunity to improve energy efficiency. Moreover, they lead to substantial reductions in greenhouse gas emissions from households. Households are known to account for a significant percentage of total greenhouse gas emissions in different countries (e.g., Saidur et al., 2007; Milito and Gagnon, 2008; Kenny and Gray, 2009; Kerkhof et al., 2009; Gough et al., 2011). At last count, over 75 countries with more than 80% of the world's population had energy efficiency standards or labelling policies in place (Egan, 2011). If best practice policies are adopted worldwide, standards and labels could result in emission reductions of approximately 0.7 $GtCO_2e$ in 2020.[37]

Energy-efficiency standards are regulations that prescribe the energy performance of manufactured products, sometimes prohibiting the sale of products that are below a minimum level of efficiency. There are three types of energy-efficiency standards:

- ***Prescriptive standards*** require that a particular feature or device be installed in all new products.
- ***Performance standards*** specify minimum efficiencies or maximum energy consumption levels that manufacturers must achieve in products. They specify the energy performance but not the technology or design details of the product.
- ***Class-average standards*** specify the average efficiency of a class of manufactured products, allowing each manufacturer to select the efficiency level for each model, such that the overall average is achieved.

Energy-efficiency labels are affixed to manufactured products to describe the product's energy performance, usually in the form of energy use, efficiency, or energy cost. The labels provide consumers with the necessary information to make informed purchases. There are two basic types of labels:

- ***Endorsement labels*** are essentially "seals of approval" given according to specified criteria.
- ***Comparative labels*** allow consumers to compare performance among similar products using either discrete categories of performance or a continuous scale.

Standards and labelling programmes have the potential to significantly affect energy consumption in the residential, commercial, and industrial sectors in the next several decades, since much of the equipment that will use energy in the buildings sector in 2020 has yet to be installed. Developing robust standards and labelling programmes now can avoid "lock-in" of inefficient equipment and lead to the realization of significant emission reductions. To illustrate, it is estimated that the minimum energy performance standards implemented from January 2010 through April 2011 by member governments of the Super-efficient

37 CO_2 savings estimates are from the Bottom-up Energy Analysis System (BUENAS), a model developed by Lawrence Berkeley National Laboratory (LBNL) and CLASP, and scaled up to a global estimate from the 62% of global final energy demand currently included in the model.

Equipment and Appliance Deployment (SEAD) Initiative[38] will yield savings of approximately 125 $MtCO_2$ in 2020[39], which is as much energy as produced by roughly seventy five 500 MW coal-fired power plants.

Appliance standards and labelling moves fairly quickly compared to other emissions reduction policies. However, there can be significant time lags between the time a government decides to regulate an appliance and actual emission reductions. In the USA for example, the supporting analyses required by law may take approximately two years. Once a new regulation is passed, it will often have a waiting period of about three years before implementation. Once implemented, emission reductions will accrue over the lifetime of the appliance, which may be up to 10-15 years.

Because labels do not eliminate products from the market, they have a lower regulatory burden and require less complicated analysis than standards. Therefore, labels can generally be implemented more quickly than standards, but it is evident that labelling without standards is less effective as a mitigation policy.

Policies that work

Standards and labelling policies are appropriate in most cultures and markets and are increasingly seen as a main tool for governments to address rising energy consumption and emissions in the appliance sector. Employing a combination of standards and labels allows for a larger impact on energy efficiency throughout the energy performance spectrum in each product class. One determining factor for the selection of the most effective standards and labelling combination is the product's current energy efficiency in the market. Other conditions that affect policy choices may include the maturity of the programme, the presence or absence of domestic manufacturing, the level of consumer awareness, and the cost of electricity.

Governments around the world have made extensive use of minimum energy performance standards and labelling programmes to improve the energy efficiency of appliances and equipment, and thereby reducing appliance sector emissions. A recent example of minimum energy performance standards is Australia's phase-out of incandescent lamps over the period from 2007 to 2010, estimated to cut Australia's greenhouse gas emissions by approximately 0.14% (Department of Environment, Water, Heritage and the Arts, 2009). This phase-out approach using minimum energy performance standards is the model being promoted by UNEP's en.lighten initiative[40], a public-private partnership led by UNEP, the Global Environment Facility (GEF) and lighting industry partners aimed at phasing-out inefficient lamps in developing countries.

Variations of the minimum energy performance standards approach include Japan's Top Runner Programme[41] and the European Union's Ecodesign Directive[42]. The Top Runner approach identifies the most energy efficient product on the market in a product category, and uses that efficiency as the class average standard (Top Runner Standard) for all products at the next standard setting period, usually the next 3-7 years. The EU's Ecodesign scheme establishes a framework for setting requirements for relevant environmental characteristics of energy related products. The level of energy efficiency or consumption is set to minimize the life-cycle energy cost to end-users, while also taking into account other environmental impacts. The Top Runner and Ecodesign Directive approaches have led to residential energy savings of 11% in Japan and 16% in the EU (Siderius and Nakagami, 2012).

For labelling programmes, the USA's ENERGY STAR voluntary endorsement label has been successful in increasing market availability and consumer awareness of efficient products, and is also used as a model by other countries. As one of the first successful consumer-oriented labelling programmes, ENERGY STAR gained critical support from manufacturers in its early days, and then increased the stringency of the programme once it became an important and well-known label to consumers.

Standards and labelling have been successful in developing countries as well. For example, Ghana initiated a standards and labelling programme in 2005 with a minimum energy performance standard for room air conditioners, which is expected to save consumers and businesses an average of US$64 million annually in energy bills and reduce emissions by about 2.8 $MtCO_2e$ over 30 years[43].

Drivers and co-benefits

One of the factors that encourage the development of energy efficiency policies is that, from a societal perspective, improving energy efficiency is generally more economically efficient than increasing energy supply.

Similar to the co-benefits of building codes, energy-efficiency standards and labelling policies reduce electricity use, which reduces fuel combustion in electric power plants and the associated impacts from extracting, transporting, and burning such fuels. Such cost-effective reduction in overall fuel combustion not only improves a nation's economic efficiency, but it also benefits nations by lowering consumers' energy bills, making energy services more affordable and improving public and environmental health. In the USA alone, additional efficiency improvements in 14 key product classes could result in US$300 billion cumulative savings to consumers by 2030 (McNeil et al., 2011).

Lessons and scope for scaling up

The success of minimum energy performance standards and product labelling depends on selecting and designing

38 SEAD is an initiative of the Clean Energy Ministerial. Member governments include: Australia, Brazil, Canada, the European Commission, France, Germany, India, Japan, Korea, Mexico, Russia, South Africa, Sweden, the United Arab Emirates, the United Kingdom, and the USA. These economies are responsible for about one half of global energy demand.

39 Energy and CO_2 savings estimates are from the Bottom-up Energy Analysis System (BUENAS), a model developed by Lawrence Berkeley National Laboratory (LBNL) and CLASP. These estimates include the following SEAD member governments: Australia, Canada, EU, Korea, Mexico, and USA. These estimates do not include the following SEAD member governments: Brazil, India, Japan, Russia, South Africa, the United Arab Emirates, and EU members France, Germany, Sweden and the United Kingdom.

40 For further details, see http://www.enlighten-initiative.org/portal/Home/tabid/56373/Default.aspx

41 For further details, see http://www.eccj.or.jp/top_runner/index.html and http://www.climatepolicy.jp/thesis/pdf/09035dp.pdf

42 For further details, see http://ec.europa.eu/enterprise/policies/sustainable-business/documents/eco-design/legislation/framework-directive/index_en.htm

43 Energy and CO_2 savings numbers from the Policy Analysis Modelling System (PAMS), a model developed by Lawrence Berkeley National Laboratory (LBNL) and CLASP.

rules and regulations that meet the specific needs of a country and its particular objectives. Additional market-based incentives or informational policy options generally support standards and labelling but do not displace standards and labelling in cost-effectiveness. It is also clear that a combination of standards and labelling is more effective than either instrument alone, and mandatory schemes are generally more effective than voluntary ones. Experience shows that successful standards and labelling policies are usually preceded by rigorous cost-benefit analyses to ensure that they generate economic benefits even in the absence of a carbon price.

Comparability among regulations and test methods for a product is critical for encouraging more stringent policies, as it helps countries understand what efficiency levels are possible based on what other programmes have accomplished. Other factors important to the success of standards and labelling programmes and to their scaling up include (Weil and McMahon, 2005):

- Availability of trained, competent personnel;
- Availability of institutions capable of implementing change in the sector;
- Existence of the political will to support implementing agencies in fulfilling their mandate;
- Existence of product testing capabilities or the ability to establish them;
- Availability or ability to establish the necessary measurement, verification and enforcement infrastructures; and
- Consultations with all stakeholders involved in the manufacture and sale of targeted products to ensure acceptance and encourage manufacturers to adopt the standards.

Finally, policies should be reviewed and revised regularly, possibly every 3-5 years, to increase stringency and drive continued energy savings. For standards, the development of improved and cost-effective energy saving technologies should be encouraged, so as to enable more stringent standards. For labels, especially non-categorical ones, once the market becomes too saturated with highly efficient products, it becomes more difficult for consumers to differentiate among the most efficient products. Hence, it is important to regularly increase the stringency of labels in order for them to remain meaningful to consumers.

Establishing appropriate institutions and processes takes time. The same applies for conducting techno-economic analyses to identify priority products and establish savings potentials, and the testing of methodologies and establishment of verification procedures. In the case of product labelling, additional time and investment in communications and outreach will be required to build up awareness and trust.

4.3.3 Best practice policies in the transport sector

Introduction

The rapid motorisation characterising 20th Century development, while resulting in economic growth and improved quality of life, has produced many adverse consequences such as traffic congestion, air pollution, unsafe roads and social inequalities. At the same time, the transport sector has the highest projected growth rate of greenhouse gas emissions and currently accounts for 13% of global greenhouse gas emissions. As noted in section 4.2, the sector also has significant potential for cutting emissions, estimated at 1.7-2.5 $GtCO_2e$ in 2020, including aviation and marine sources (ICCT, in press). In the past, transportation development focused on improvements for higher-emitting private vehicles. At present there is a move towards more sustainable transport, as indicated by the eight biggest multilateral development banks pledging US$175 billion for sustainable transport over the next decade at the Rio+20 UN Conference on Sustainable Development in June 2012.

Sustainable transport represents a shift in the way transport infrastructure is approached, focusing on moving people rather than vehicles through mass transit, walking and cycling, and inland waterways. Along with this shift, a framework focusing on “Avoid”, “Shift” and “Improve” policies and measures (see below) is increasingly being adopted. A variety of successful policies within these three categories have been in place for decades in countries around the world (Pucher and Buehler, 2010).

Avoid policies – aim and examples

These policies have an overall aim of avoiding or reducing trips, thereby reducing the generation of vehicle-kilometres[44] and subsequently greenhouse gas emissions.

A key focus is to promote comprehensive planning of new communities, or the redevelopment of economically depressed or polluted areas, focusing on mixed-uses with access to mass transit. Integration of land-use policies, transport planning and the development of new urban areas around transit corridors is an example of a comprehensive “avoid” policy package. This can be a central policy option in emerging economies to prevent growth in the use of private vehicles and associated increases in future emissions from the transport sector. Transit-oriented development is one example of such an “avoid” policy, discussed later in this section.

Avoid policies often use a range of instruments that in addition to planning may comprise economic, regulatory and information instruments (Sakamoto et al., 2010). Examples of such instruments include elimination or reduction of fossil fuel subsidies; and pricing mechanisms designed to change behaviour and incentivize people not to use individual vehicles. Other examples are fiscal mechanisms such as emissions-based road use charges for freight vehicles to encourage improved loading and routing and a reduction of empty movements; and, encouraging the use of telecommunication to reduce travel.

“Shift” policies – aim and examples

These policies promote shifts to the lowest greenhouse gas emitting modes of transportation and discourage shifts from walking, cycling, and public transport to private vehicles by improving the quality of public transport. Creating a transport

44 Vehicle-kilometres is a measure of traffic flow. It is a unit of measurement representing the movement of a road motor vehicle over one kilometre (http://glossary.eea.europa.eu/terminology/concept_html?term=vehicle-km)

Bus and bicycles, Malmo, Sweden. Credit: Tupungato/Shutterstock.com

environment that facilitates "shift" requires development of a system of alternatives that has higher utility to users than private vehicles, which among other factors, implies that services must be high-quality and reliable as well as accessible to a large proportion of the population. The system should also allow easy transitions between the different transportation modes through physical, operational and fare integration. Examples include Bus Rapid Transit (BRT) (e.g., Ahmedabad, Bogota, Guangzhou, Johannesburg, Los Angeles, Mexico City and Rio de Janeiro), Bike Share Systems (e.g., Copenhagen, Hangzhou, London, Mexico City and Paris), Rail-based mass transit (e.g., Berlin, Hong Kong and New York), Pedestrian and Cycling network development (e.g., Copenhagen and Guangzhou), Parking Management (e.g., Budapest, San Francisco and Zurich), and Intermodal freight System Management (e.g., Germany). Bus Rapid Transit systems are discussed later in this section.

Similar to "avoid" policies, a number of instruments are available to support "shift" policies and often a combination of such instruments will be appropriate. In addition to the planning, economic, regulatory and information instruments already mentioned above, technology-focused instruments are also available to support "shift" policies (Sakamoto et al., 2010). For example, instruments aimed at increasing vehicle efficiency, through technologies for engine transmission and driveline improvements, hybrid systems, lightweight materials or further development of low carbon and alternative fuels, can be part of "shift" policies (Dalkmann and Brannigan, 2007).

"Improve" policies – aim and examples

These are policies aimed at improving the energy efficiency of vehicles and fuels through the introduction of new vehicle technologies and policies, including vehicle performance standards, voluntary programmes, fiscal mechanisms, low carbon and alternative fuels, financial subsidies for advanced vehicle technologies, fleet scrappage programmes, amongst others. The aim is to ensure that future vehicles and fuels are cleaner, and to encourage efficient vehicles (Dalkmann and Sakamoto, 2012). Best practices for vehicle performance are discussed later in this section.

The Avoid-Shift-Improve framework has been devised to support governments and institutions at all levels to develop better and more comprehensive approaches to transport planning, urban mobility, and commodity flows. The following examples describe best practices, barriers, and opportunities within the Avoid-Shift-Improve framework.

"Avoid" policies that work: transit-oriented development

Transit-oriented development is the practice of mixing residential, commercial and recreational land uses to promote high-density neighbourhoods around public transit stations. One of the earliest and most successful examples of transit oriented development comes from Curitiba in Brazil. In the 1970's the city government actively promoted the organization of the city along high-density transit corridors. It integrated zoning laws and transportation planning into the city's master plan. It also created pedestrian malls, instituted parking policies and developed cost-effective Bus Rapid Transit corridors.

The availability of comprehensive studies of the emission reduction potential of transit-oriented development is limited. However, a study for the USA estimates that applying transit-oriented development best practices could both reduce vehicle-kilometres by 10% from 2005 levels and cut annual greenhouse gas emissions by 145 million tonnes of CO_2e in 2030, the equivalent of some 30 million cars in the USA or 35 large coal power plants (Winkelman et al., 2009). Importantly, the study finds that these reductions are associated with significant economic benefits, yielding net cost savings per tonne of CO_2, when avoided costs for infrastructure, fuel, insurance and projected tax revenues from economic development, are taken into account.

"Shift" policies that work: Bus Rapid Transit

Bus Rapid Transit systems can provide the high-quality service needed to maintain a strong public transport system. In addition to the construction and operational features that can make BRT run smoothly, some of the key elements are frequent, high capacity service, higher operating speeds than conventional buses, separated lanes, distinct stations with level boarding, and fare prepayment and unique branding (Owen et al., 2012).

Since the 1970s, BRT has expanded to more than 100 cities around the world, with the largest increase taking place during the last 10 years. BRT or similar systems are now in place in many cities in Latin America, Asia, North America, and Europe and represent approximately one percent of the global modal split. Despite many institutional and policy challenges, these systems have been adapted to a range of different physical and regulatory environments.

The number of BRT systems has increased because they can reliably move large numbers of people and reduce travel times. Their expansion is also explained by the fact that the capital costs of BRT systems are between one-third and one-tenth of that of rail system costs.

Although BRT systems lead to lower emissions than many other transit options, they are usually constructed for other reasons, for example, to reduce local air pollution, traffic fatality rates, and road congestion (Transmilenio, 2011). There is a lack of studies assessing the emission reductions achieved through BRT, although project level estimates exist. For instance, in Bogota, Colombia, BRT is estimated to have resulted in emission reductions of 1.7 million metric tons CO_2e over seven years[45] (see also Box 4.2).

Barriers to more rapid expansion of BRT include inadequate fare levels and the fact that there is sometimes a preference for rail systems without adequate analysis of alternatives.

Furthermore, overcrowding and deterioration of roadways in some places make BRT less attractive to potential users. Transit agencies can play an important role in maintaining the attractiveness of BRT through service and operation improvements and through communication with the public (Weber et al., 2011). To illustrate, Jaipur City Transportation Service increased their ridership over 100% in one year by improving the fare structure, colour-coding bus routes, and improving operation by conducting adequate analysis of operations and cost data (Jain, 2011). The example of Jaipur city shows that large investments in infrastructure and technology are not always needed to create a "shift".

Lessons and scope for scaling up transit oriented development and bus rapid transit

In light of the attractiveness of combined sound land use policies such as transit oriented development and bus rapid transit, many cities are looking at replicating these "avoid" and "shift" policy practices. They provide significant benefits from a social and private perspective in addition to curbing growth in emissions from transportation. Some of the key principles that could facilitate the scaling up of transit-oriented development and BRT programmes are:

(i) Identifying and assessing the co-benefits, such as road safety, improved air quality, job creation, social equity and health benefits, among others, in order to leverage political support.

(ii) Implementing the highest standard from the onset in order to minimise public discontent and makes future expansion and further investment easier.

(iii) Improving accessibility through the integration of transit with active modes and surrounding land uses in order to attract citizens out of their private vehicles.

(iv) Developing strong institutional support at the national, regional and local level to facilitate and ensure:
- the efficiency of passing legislation and regulations,
- the creation of comprehensive land use development policies, and
- the improvement of infrastructure finance mechanisms.

(v) Engaging industry early-on to identify appropriate technologies, lower costs, streamline procurement procedures, and create a proper finance structure.

Box 4.2 Mexico City Metrobus system

Metrobus in Mexico City is a successful example of "shift", where 10% of BRT riders have shifted from private cars (Investigaciones Sociales Aplicadas, 2007). From its inception in 2005, it has grown to a system with four lines, covering 95 km, and serving 687,000 passengers per day (City of Mexico, 2012). The location of the routes and stations along popular corridors makes the service attractive and easy to access for pedestrians. In addition, formalizing service and reducing mixing in traffic has reduced the number of road fatalities along the corridor.

Annually:
- 169 million passengers are served
- 36.7 million travel hours are saved
- 143,000 tons CO_2 emissions are avoided
- and approximately 23 lives are saved

Note: EMBARQ calculations compared to a baseline without the BRT. Total time saved is based on average time savings per passenger trip. CO_2 emissions avoided are based on the difference between modal split in the two scenarios, distance travelled by buses, and IPCC emission factors.

45 http://cdm.unfccc.int/Projects/DB/DNV-CUK1159192623.07/view

"Improve" policies that work: Vehicle Performance Standards for New Light-duty Vehicles

This section provides an overview of vehicle performance standards for new light-duty vehicles, which establish minimum requirements based on fuel consumption or greenhouse gas emissions per unit of distance travelled. A number of regulatory approaches to reducing light-duty vehicle fuel consumption and greenhouse gas emissions have evolved through the last several decades, relying on different test procedures, formulas, performance-based attributes and baselines. Seven countries including Australia, Canada, China, the European Union, Japan, South Korea, and USA, have established or are in the process of revising light-duty vehicle fuel consumption or greenhouse gas emission standards.

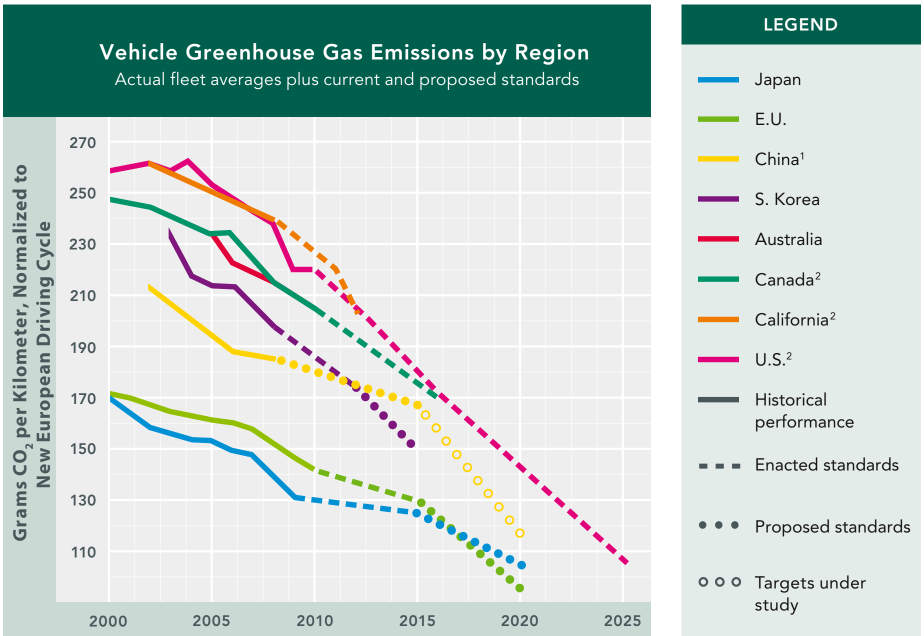
These standards have a proven track record for achieving vehicle efficiency improvements. Approved and proposed vehicle performance standards are expected to reduce fuel consumption and greenhouse gas emissions of the new light-duty fleet in these countries by over 50% by 2025 from 2000 levels (see Figure 4.2) (ClimateWorks Foundation and ICCT, 2012). Because these standards have been implemented at the national level, their effects on total greenhouse gas emission reductions are substantial. Adopted vehicle performance standards for the light-duty fleet are estimated to result in emission reductions of 0.8 $GtCO_2e$ globally in 2020 (ICCT, in press). In the case of the USA, the standards targeting model years 2012–16 are expected to save each car owner about US$3,000 over the life of the vehicle (USA. Environmental Protection Agency and National Highway Traffic Safety Administration, 2010). Vehicle performance standards also stimulate technology innovation by requiring automakers to build more efficient vehicles. Substantial improvements in vehicle efficiency can be realized through engine transmission and driveline improvements, hybrid systems, lightweight materials and better aerodynamics and rolling resistance.

Lessons and scope for scaling up

There are several key principles for successful introduction of vehicle performance standards including:

(i) standards should be technology-neutral[46] so that markets find the most cost-effective solution;
(ii) standards should be made continuously more stringent – by 3 to 6% annually – to encourage on-going innovation and send long-term signals to automakers (ClimateWorks Foundation and ICCT, 2012);
(iii) standards should include all vehicle classes to prevent loopholes;
(iv) standards should not be weight-based, but footprint-based so they no longer discourage the use of lightweight materials;
(v) countries should improve testing procedures and rules so that test vehicle efficiency closely reflects real-world performance; and,
(vi) countries should combine vehicle performance standards with fiscal mechanisms and vehicle scrappage programmes that can help incentivize purchase of the most efficient vehicles and speed up the turnover of the existing fleet.

These international best practices for successful policy design can also be used to strengthen standards in places where they already exist. Designing effective standards requires strong institutional support from the governmental agencies that hold the regulatory authority to approve the standards, as well as extensive technical expertise and knowledge of international results to apply lessons learned from other countries.



Passenger vehicle fuel economy standards have substantially reduced CO_2 emissions.

[1] China's target reflects a gasoline fleet scenario. If other fuel types are included, the target will be lower.

[2] U.S. and Canadian light-duty vehicles include light commercial vehicles.

Figure 4.2 Vehicle GHG emissions by region. *Source: ClimateWorks Foundation and ICCT, 2012.*

46 That is, standards should not advocate a specific technology

4.3.4 Best practice policies to curb deforestation

Introduction

Forests provide major ecosystem services such as watershed protection and biodiversity conservation, as well as livelihoods for around 1.6 billion, mostly poor, people (Chao, 2012). Greenhouse gas emissions from the forestry sector are caused by deforestation and forest degradation. These emissions, which constitute the largest non-energy source of greenhouse gas emissions, are estimated to be 4.4 $GtCO_2e$/yr in 2008, and represent about 11% of global anthropogenic CO_2 emissions (see Chapter 2).

Deforestation is mainly caused by expansion of agricultural frontiers (Angelsen, 2010; Pfaff et al., 2010), while forest degradation can be caused by natural phenomena (e.g., diseases and pests, storms, fire, drought and other climatic stresses) or by anthropogenic factors (e.g., air pollution, fire, economic overexploitation and overgrazing) or by a combination of both natural and anthropogenic factors (EEA, 2011).

Although it has remained under-utilized, "avoided deforestation[47]" is considered a low-cost greenhouse gas emissions reduction option (IPCC, 2007). While the annual rate of tropical deforestation decreased from 160,000 km^2 in the 1990s to 130,000 km^2 in the 2000s (FAO, 2010), it is believed that significantly greater reduction in deforestation is achievable.

The following sections describe policies that are effective at curbing deforestation. Four distinct policy categories are presented:

Establishing protected areas: This involves designating some forest areas as protected areas[48]. This is arguably the most common policy instrument for preserving tropical forests. It is generally effective in preventing deforestation, but is even more effective when the protected areas are close to expanding frontiers (e.g., expanding agricultural frontiers) rather than in remote low-threat areas (Joppa and Pfaff, 2010; Pfaff et al., 2010; Nelson and Chomitz, 2011).

Using command-and-control measures: This involves the enactment and enforcement of environmental regulations and putting in place adequate monitoring structures to ensure compliance (Hargrave and Kis-Katos, in press).

Using economic instruments: This involves the use of economic tools such as taxes, subsidies and payments for ecosystem services for encouraging forest conservation (Angelsen, 2010; Pfaff et al., 2010).

Creating policies affecting drivers and contexts: This involves creating or changing sectoral policies, institutional frameworks and governance structures so as to influence the dynamics of deforestation (Angelsen, 2010; Pfaff et al., 2010).

Successful national strategies for curbing deforestation have typically included a combination of these categories (Chomitz et al., 2007). Brazil and Costa Rica stand out as examples of countries that have successfully sustained anti-deforestation policies with large-scale results. The section below takes a closer look at policies in these countries and how their successful experience may be reproduced elsewhere.

Policies that work

In Brazil, recent deforestation has occurred mostly in the Amazon, so we focus on policies applied there. The Amazon forest is the largest tropical forest on earth, holding a significant share of the world's biodiversity and 66±7 GtC, or 23% of the world's forest carbon[49] (Saatchi et al. 2007; FAO, 2010). Deforestation in the Brazilian Amazon reached its second highest historical level in 2004 (27,772 km^2), and was responsible for the emission of around 1.1 $GtCO_2e$. Since then, deforestation has decreased by three-quarters (6,418 km^2 in 2011) (INPE-EM, 2012). Public policies contributed substantially to this reduction (CEPAL/IPEA/GIZ 2011). One estimate suggests that they were responsible for about one-half of the reduction between 2005 and 2009, or 0.6 $GtCO_2e$. The remainder has been attributed to lower agricultural commodity prices (Assuncao et al., 2012). Compared to the country's official BaU scenario[50], Brazil avoided 2.8 $GtCO_2e$ in emissions from 2006 to 2011 (Brazil. Ministry of Environment of Brazil, 2012).

Costa Rica has gone from very high annual deforestation rates (around 3 to 4% of its forest area/year) during the 1960s and 1970s to close to zero forest loss today (Camino et al., 2000; Sánchez-Azofeifa et al., 2007).[51] Public policies were also important drivers of this change, together with structural economic changes (Camino et al., 2000; Sánchez-Azofeifa et al., 2007; Robalino et al., 2008; Brown and Bird, 2011).

Protected areas: In the last decade, Brazil has increased its Amazon protected areas, indigenous lands and sustainable-use areas by a significant 709,000 km^2 representing 45.6% of the Amazon biome in 2009 (Soares-Filho et al., 2010). Much of the recent expansion of protected areas occurred near especially threatened areas (CEPAL/IPEA/GIZ, 2011). The expansion of protected areas has significantly decreased both Amazon fire incidence and deforestation (Chomitz and Thomas, 2003; Nepstad et al., 2006; Arima et al., 2007; Soares-Filho et al., 2010).

Protected areas in Costa Rica represent 24% of its territory (1.2 million ha) and are used more intensively than in Brazil, especially for ecotourism (Hoffman, 2011)[52]. Tourist numbers increased from 387,000 in 1988 to 2.5 million in 2008, when tourism reached 15% of GDP. Ecotourism alone now brings in more foreign currency than livestock exports did previously (Camino et al. 2000; Brown and Bird, 2011; Christian et al., 2011).

Command-and-control measures: During the 2000s, Brazil invested heavily in modernizing its satellite-based monitoring strategy. Detailed deforestation data has directly supported field-based law enforcement in real time, and

47 Avoided deforestation is the prevention or reduction of deforestation in order to decrease greenhouse gas emissions.

48 A protected area, according to IUCN, is "a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values" (Dudley, 2008).

49 Considering only carbon stored on above ground live biomass.

50 The official BaU scenario assumes 19,535 km^2 of annual deforestation, which equals the 1995-2006 average.

51 Some disagreement about forest cover changes in Costa Rica remains (Sánchez-Azofeifa et al. 2007)

52 One specific marketing advantage for Costa Rica is its closeness to the American market.

enforcement teams can now reach new deforestation spots a few days after its detection (INPE, 2008). Furthermore, the federal environment police (IBAMA) was modernized and innovative enforcement measures to combat deforestation, such as confiscation of illegally used assets (e.g., cattle, timber and machinery) and area-based trade embargos were adopted. Federal prosecutors also made slaughterhouses and supermarkets liable for offences by suppliers involved in illegal deforestation. Several studies indicate improved law enforcement as a key to reduced deforestation (Barreto and Silva 2010; CEPAL/IPEA/GIZ, 2011; Hargrave and Kis-Katos, in press). After 2007, Brazil's federal government blacklisted high-deforesting municipalities (up to 42 out of 756) and carried out law enforcement raids, embargoes, and other actions. Concentrating on selected targets was not only cost-efficient, but also made local mayors share responsibility for deforestation (CEPAL/IPEA/GIZ, 2011).

In Costa Rica, command-and-control measures were also part of the policy mix, though somewhat less prominently compared to Brazil. A complete ban on forest conversion was adopted already in 1997. Although, enforcement was not always 100% effective, the task was generally easier than in the Amazon, due to smaller forest size, lower agricultural land pressures, and clearer land-tenure arrangements (Camino et al., 2000; Sánchez-Azofeifa et al., 2007).

Economic instruments: In Brazil, economic instruments have so far played a relatively small role. By contrast, Costa Rica is a model for using forest-based economic instruments in the developing world. This has included applying forest conservation and reforestation incentives on private farms (Brown and Bird, 2011). From 1979 to 1990, policies focused on tax breaks for plantations and natural forest conservation (Camino et al., 2000; Brown and Bird, 2011). After 1991, direct subsidies for farm-level forest conservation were introduced, culminating from 1997 onwards in the programme of payments for ecosystem services (PES) (protection of watersheds, carbon stocks, biodiversity, and natural beauty). PES was predominantly financed by a new tax on fossil fuels and by international financing (Camino et al., 2000; Brown and Bird, 2011).

Many argue that economic incentives were central to Costa Rica's conservation success (Sánchez-Azofeifa et al., 2007; Robalino et al., 2008). The effectiveness of PES remains uncertain though, because deforestation was already small when PES policies were introduced (Pagiola, 2008).

Policies targeted at drivers and contexts

Traditionally, Costa Rica subsidized forest conversion for crops and pastures. Falling commodity prices, economic crisis and structural adjustment programmes in the 1980s were key factors for phasing out these incentives and curbing land clearing (Camino et al., 2000; Kleinn et al., 2002; Brown and Bird, 2011). Well-defined land tenure (Brown and Bird, 2011) also lowered pressure for forest conversion. This contrasts with the Amazon, where land appropriation by homesteaders (clearing land to establish or consolidate property rights) was an important driver of deforestation.

Compared to the Amazon's abundant forest, Costa Rica's forests became scarcer earlier, which gradually led to a political commitment to address deforestation and promote sustainable forest management. Costa Rica experienced a typical turning point in its 'forest transition', with rising wages and urban employment pulling workers from farms into cities (see Rudel et al., 2010). Costa Rica's high level of commitment to economic and human development, and sustainable development, were also instrumental.

In Brazil, stagnating commodity prices (soy, beef) from the mid-2000s explain part of the decrease in deforestation (Barreto and Silva, 2010; Soares-Filho et al., 2010; Assuncao et al., 2012). But Brazil also managed to mobilize widespread internal political support for curbing deforestation. Bringing the deforestation agenda into the President's Cabinet created unprecedented political will to coordinate anti-deforestation policies across ministries. Policies were bundled into a single strategy which covered 14 government ministries. This was a major factor in the success story of curbing deforestation (CEPAL/IPEA/GIZ, 2011).

Scope for scaling-up

The previous sections illustrate that policies to curb deforestation typically require cross-sector policy coordination involving multiple stakeholders. Similarly, a policy mix of incentives, disincentives, and appropriate enabling policies may be most appropriate. But which enabling factors are key to replicating and scaling-up successful policies?

First, countries may learn from the Brazilian experience, where the capacity to properly monitor deforestation was a key factor in reducing deforestation. Monitoring can be strengthened without major changes in regulation or political support, and requires mainly financial resources and technology transfer.

Second, to achieve large-scale results, countries need strong political commitment from the core of government. In both Costa Rica and Brazil, this provided the basis for developing and implementing comprehensive strategies across sectors and levels of government.

Third, as stated earlier, protected areas generally have an important impact on conserving forests, but they can be even more effective if they are positioned near deforestation frontiers or areas liable to future threats. Protected areas with sustainable use of natural resources[53] provide an interesting compromise between local livelihoods and environmental interests, and could therefore serve as an option in areas where there is conflicting interest between forest conservation and local livelihoods.

Fourth, in Brazil, a sudden increase in enforcement of existing forestry laws triggered strong reactions from agricultural interests against the laws (Barreto and Araujo, 2012). To avoid a similar situation, countries may have to combine enforcement with new legislation and institutions. Costa Rica's combination of incentives, disincentives and enabling measures is a noteworthy example of an easy-to-accept policy mix.

53 According to IUCN, a "protected area with sustainable use of natural resources" refers to an area designated for the purpose of "conserving ecosystems and habitats together with associated cultural values and traditional natural resource management systems. They are generally large, with most of the area in a natural condition, where a proportion is under sustainable natural resource management and where low-level non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area" http://www.iucn.org/about/work/programmes/gpap_home/gpap_quality/gpap_pacategories/.

Rio Negro in the Amazon River basin, Brazil. Credit: AND Inc/Shutterstock.com

Fifth, well-defined land tenure can provide an incentive for conserving forests. Once stronger institutions and secure property rights to forest lands have been established, economic incentives for conservation in private properties may become nationally applicable, rather than restricted to pilot projects. To maximize effectiveness, PES schemes may target areas where deforestation risks and forest services such as medicinal plants, watershed protection, and lumber are most abundant.

Finally, economy-wide policies can in some cases be one of the underlying causes of deforestation. While some land-clearing incentives, such as global commodity prices, are usually outside a particular government's control, others including taxes, subsidies, credit provision, and regulations, are not. Removing perverse national policy incentives may reduce both government budgets and forest pressures, resulting in a win-win situation.

It is noteworthy that changes in Brazilian and Costa Rican policies pre-dated the adoption of the Reduced Emissions from Deforestation and forest Degradation (REDD+) policies under the UNFCCC. In Costa Rica, the main motivation was to support forest owners producing domestic environmental services (watershed protection and touristic landscape beauty). In Brazil, national and international public opinion exerted political pressure favouring protection of the Amazon, due to co-benefits linked to conservation. A focus on such benefits may thus also render climate change mitigation strategies more politically viable.

Currently, REDD+ seems to provide low-cost opportunities for mitigating emissions (Streck and Parker, 2012) while producing important co-benefits (Strassburg et al., 2012). National anti-deforestation policies and on-the-ground pilot projects are both considered core to REDD+. Most tropical forest-rich countries are already designing their REDD+ strategies, and developed countries have been, in turn, requested to scale up short- and long-term financing. In most cases, REDD+ strategies will need to adopt customized policy mixes to become effective. The cases of Costa Rica and Brazil can help provide some of the ingredients.

4.4 Conclusions

The analysis of studies published in the past year do not change estimates of the total mitigation potential in 2020 of 17 ± 3 $GtCO_2e$ identified in the Bridging the Emissions Gap Report (UNEP, 2011). However, while the emission reduction potential remains significant, time is running out. Delays in action will gradually reduce the 2020 mitigation potential because of emissions "lock-in".

It is also known that emission reduction potential can only be realized if strong, long-term and sector-specific policies are in place at the global and national levels. The good news is that a wide range of policies, successful in cutting greenhouse gas emissions, have already been adopted in various sectors and countries. The second part of this chapter analysed how such ambitious, sector-specific policies can be instrumental in achieving the emission reduction potential.

Although market-based instruments play a crucial role for emission reductions, experience has shown that market imperfections, including information asymmetries and undefined property rights, limit the application of such instruments. Additionally, some of the key decisions that affect emission trajectories for decades and, in some cases, centuries, are not market-based. For this and other reasons, command-and-control instruments such as codes, standards, labels and zoning, together with price-based policy instruments such as taxes or payments for environmental services, should all be part of the considered options, depending on national and local circumstances.

The political feasibility of introducing ambitious regulatory measures such as standards and regulations is higher in some sectors, such as buildings and transportation, which are intrinsically local. The same is true for most of the timber extraction in tropical forests when it is directed to domestic markets. However, the range of benefits associated with the implementation of the policies described in this chapter is so wide (reduction in energy consumption and prices, improved air quality, increased environmental services from forest protection, etc.) that these examples should motivate national and local governments around the world to replicate or expand similar policies.

Clearly, successful scale-up of the policies described in the chapter requires that the instruments be tailored to local economic, financial and social conditions, such as the existing capital stock, weather and urbanization patterns, technical capacity, and economic and demographic trends. Forest policies, for example, must account for the existing variety of ecological and economic aspects of land use. The presence of effective institutions is also crucial to the successful implementation of policies. The availability of appropriate monitoring and enforcement mechanisms are also a key to success.

Creating the right conditions for effective policies can take time even when there is strong political will. Ideally, policy design needs to be strong enough to resist the volatility of electoral cycles.

This chapter can be viewed as an attempt to provide policymakers with an understanding of how certain policies can also be significantly leveraged to help bridge the emissions gap.

Among the key findings of this chapter, three stand out. Firstly, many developed and developing countries have already taken action to implement sector-specific policies that, in addition to reducing carbon emissions, have also proven effective at delivering a wide range of other benefits. These have included, saving money, reducing air pollution, improving public health, strengthening energy security and creating jobs. In fact, in most of the examples presented in this chapter, the case for policy implementation was triggered by national and local interests, rather than climate concerns.

Secondly, while it is encouraging that so many countries are actively pursuing targeted, sector-specific policies with the potential to significantly reduce greenhouse gas emissions, the window for closing the emissions gap is getting narrower as we get closer to 2020. Since today's investments in buildings, transportation systems, factories, and cities will set future energy use patterns for decades, early policy action at the national and local level is essential to avoid emissions "lock in", and prevent energy waste and excessive pollution. Losses, often permanent ones in carbon storage and in biodiversity, can be avoided with effective deforestation policies that create norms and incentives for good land use.

Thirdly, the considerable progress in sector-specific policy implementation has the potential to make the adoption of a coherent climate policy more likely, both at the national and international level. The scaling up of effective policies both in terms of ambition and geographical reach is certainly challenging, but it is also feasible, as the cases analyzed here suggest. If pursued broadly, these successful policies would set the world on a more sustainable climate trajectory.

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EP #12-82946

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ISBN: 978-92-807-3303-7
Job. No: DEW/1614/NA